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(54) **Title:** CAMERAS WITH SCANNING OPTICAL PATH FOLDING ELEMENTS FOR AUTOMOTIVE OR SURVEILLANCE APPLICATIONS

(57) **Abstract:** Systems including dual-aperture zoom digital cameras with scanning optical path folding elements (OPFEs) for automotive or surveillance applications and methods for operating and using same. In some embodiments, a dual-aperture zoom digital camera comprises a Wide camera with a Wide field of view FOV_W, a Wide sensor and a Wide lens, wherein the Wide camera is operative to output Wide image information, a Tele camera with a Tele field of view FOV_T smaller than FOV_W and with a Tele sensor, a Tele lens with a Tele lens optical axis and a scanning OPFE, and a processing unit operative to detect an object of interest (OOI) from Wide and/or Tele image information and to direct the Tele camera to move FOV_T to acquire Tele image information on the OOI.

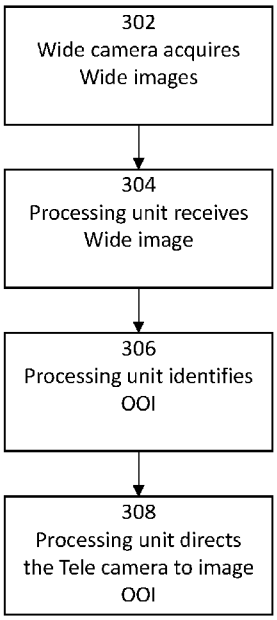


FIG. 3

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CAMERAS WITH SCANNING OPTICAL PATH FOLDING ELEMENTS FOR AUTOMOTIVE OR SURVEILLANCE APPLICATIONS

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Provisional Patent No. 62/693,951 filed July 4, 2018, the content of which application is herein incorporated by reference in its entirety.

FIELD

Embodiments disclosed herein relate in general to digital cameras and in particular to thin zoom digital cameras.

BACKGROUND

Host devices having two cameras (also referred to as "dual-camera" or "dual-aperture camera") are known, see e.g. US Patent No. 9185291. The two cameras have lenses with different focal lengths and have respective image sensors operated simultaneously to capture an image. Even though each lens/sensor combination is aligned to look in the same direction, each will capture an image of the same scene but with a different field of view (FOV). As used herein, "FOV" is defined by the tangent of the angle between a line crossing the lens and parallel to the lens optical axis and a line between the lens and any object that is captured on the respective image corner. For simplicity, “image sensor” is referred to henceforth as “sensor”.

Dual-aperture zoom cameras in which one camera has a "Wide" FOV (FOV_W) and the other has a narrow or "Tele" FOV (FOV_T) are also known, see e.g. US Patent No. 9185291. The cameras are referred to respectively as Wide and Tele cameras that include respective Wide and Tele sensors. These sensors provide respectively separate Wide and Tele images. The Wide image captures FOV_W and has a lower spatial resolution than the spatial resolution of the Tele image that captures FOV_T. The images may be merged (fused) together to form a composite image. In the composite image, the central portion is formed by combining the relatively higher spatial resolution image taken by the lens/sensor combination with the longer focal length, and the peripheral portion is formed by a peripheral portion of the relatively lower spatial resolution image

taken by the lens/sensor combination with the shorter focal length. The user selects a desired amount of zoom and the composite image is used to interpolate values from the chosen amount of zoom to provide a respective zoom image. Hereinafter, the use of "resolution" in this description refers to image spatial resolution, which is indicative to the resolving power of a camera as determined by the lens focal length, its aperture diameter and the sensor pixel size.

Dual-aperture cameras in which one image (normally the Tele image) is obtained through a folded optical path are known, see e.g. co-invented and co-owned US patent application No. 14/455,906, which teaches zoom digital cameras comprising an "upright" (with a direct optical axis to an object or scene) Wide camera and a "folded" Tele camera, see also FIG. 2B below. The folded camera has an optical axis substantially perpendicular (orthogonal) to an optical axis of the upright camera. The folded Tele camera may be auto-focused and optically stabilized by moving either its lens or by tilting an optical path folding (reflecting) element ("OPFE"), e.g. a prism or mirror inserted in an optical path between its lens and a respective sensor. For simplicity, the OPFE is referred to hereinafter generically as "prism", with the understanding that the term may refer to any other optical path folding (reflecting) element that can perform the function of folding an optical path as described herein, for example a mirror.

For example, PCT patent application PCT/IB2016/056060 titled "Dual-aperture zoom digital camera user interface" discloses a user interface for operating a dual-aperture digital camera included in host device, the dual-aperture digital camera including a Wide camera and a Tele camera, the user interface comprising a screen configured to display at least one icon and an image of a scene acquired with at least one of the Tele and Wide cameras, a visible frame defining FOV_T superposed on a Wide image defined by FOV_W, and means to switch the screen from displaying the Wide image to displaying the Tele image. The user interface further comprises means to switch the screen from displaying the Tele image to displaying the Wide image. The user interface may further comprise means to acquire the Tele image, means to store and display the acquired Tele image, means to acquire simultaneously the Wide image and the Tele image, means to store and display separately the Wide and Tele images, a focus indicator for the Tele image and a focus indicator for the Wide image.

Object recognition is known and describes the task of finding and identifying objects in an image or video sequence. Many approaches have been implemented for accomplishing this task in computer vision systems. Such approaches may rely on appearance-based methods by using

example images under varying conditions and large model-bases, and/or on feature-based methods that search to find feasible matches between object features and image features, e.g., by using surface patches, corners and edges detection and matching. Recognized objects may be tracked in preview or video feeds using an algorithm for analyzing sequential frames and outputting the movement of targets between the frames.

The problem of motion-based object tracking may be divided into two parts:

(1) detecting moving objects in each frame. This may be done either by incorporating an object recognition algorithm for recognizing and tracking specific objects (e.g. a human face) or, for example, by detecting any moving object in a scene. The latter may incorporate a background subtraction algorithm based on Gaussian mixture models with morphological operations applied to the resulting foreground mask to eliminate noise. Blob analysis can later detect groups of connected pixels, which are likely to correspond to moving objects; and

(2) associating the detections corresponding to the same object over time, e.g., using motion estimation filters such as the Kalman filter.

In automotive or surveillance applications involving cameras it would be advantageous to have the ability to inspect a certain region of interest with high resolution. If addressed by a single camera, the required spatial resolution will force the single camera to have a sensor with a very large number of pixels.

There is therefore a need to identify a specific region of interest in an image with large field of view and steer a camera with a narrow field of view to that location.

SUMMARY

In various embodiments there are provided systems comprising dual-aperture zoom digital cameras with scanning OPFEs for automotive or surveillance applications and methods for operating and using same.

In exemplary embodiments, there are provided systems comprising: a Wide camera with a Wide field of view FOV_W and comprising a Wide sensor and a Wide lens, wherein the Wide camera is operative to output Wide image information; a Tele camera with a Tele field of view FOV_T smaller than FOV_W and comprising a Tele sensor, a Tele lens with a Tele lens optical axis and a scanning OPFE; and a processing unit operative to detect an object of interest (OOI) from

Wide and/or Tele image information and to direct the Tele camera to move FOV_T to acquire Tele image information on the OOI.

In an exemplary embodiment, the system is installed in a vehicle and the processing unit is further operative to calculate a required measure-of-action or response needed from the vehicle.

In an exemplary embodiment, a system further comprises an actuator to tilt the OPFE to move the FOV_T.

In an exemplary embodiment, the processing unit is operative to direct the Tele camera to move FOV_T to substantially a center of the FOV_W.

In an exemplary embodiment, the processing unit is operative to direct the Tele camera to move FOV_T to a center of the OOI.

In an exemplary embodiment, the processing unit is operative to receive steering information from a steering wheel of the vehicle and to direct the Tele camera to move FOV_T also based on the steering information.

In an exemplary embodiment, the processing unit is operative to receive steering information from a steering wheel of the vehicle and the actuator tilts the OPFE to move FOV_T also based on the steering information.

In an exemplary embodiment, FOV_W covers a road in front of the vehicle, the OOI is a road curve and the processing unit is operative to move FOV_T to follow the road curve.

In an exemplary embodiment, the vehicle has a vehicle cabin, the OOI is located inside the vehicle cabin and the OPFE may be tilted to provide an extended Tele camera FOV (FOV_E) greater than FOV_T.

In an exemplary embodiment, the OOI is a driver of the vehicle and the required measure-of-action or response is based on a gaze of the driver.

In an exemplary embodiment, the OOI is a child and the required measure-of-action or response is a warning that the child does not wear a seat belt.

In an exemplary embodiment, the required measure-of-action or response includes a measure-of-action or response selected form the group consisting of changing speed and/or course of the vehicle, operating an internal alarm to a driver of the vehicle, operating an external alarm, sending data information to, or calling Internet/cloud based service/ police / road assistance services, and a combination thereof.

In an exemplary embodiment, the OOI is a human face.

In an exemplary embodiment, the processing unit is operative to instruct the Tele camera to move to a specific location of the human face for face recognition.

In an exemplary embodiment, the processing unit is operative to instruct the Tele camera to move FOV_T to scan parts of FOV_W in two directions.

In an exemplary embodiment, the scan is performed by the scanning OPFE with a tilting and settling time of the OPFE of between 5-50msec.

In an exemplary embodiment, the processing unit is operative to detect the OOI from Wide and/or Tele image information and to direct the Tele camera to move FOV_T to acquire information on the OOI in automatic tracking mode.

In an exemplary embodiment, the Wide and Tele image information may be fused together to form a composite image or a composite video stream.

In an exemplary embodiment, each composite image has the same field of view.

In an exemplary embodiment, a composite image is formed by stitching a plurality of Tele images.

BRIEF DESCRIPTION OF THE DRAWINGS

Non-limiting examples of embodiments disclosed herein are described below with reference to figures attached hereto that are listed following this paragraph. Identical structures, elements or parts that appear in more than one figure are generally labeled with a same numeral in all the figures in which they appear. The drawings and descriptions are meant to illuminate and clarify embodiments disclosed herein, and should not be considered limiting in any way.

FIG. 1A shows an embodiment of a system disclosed herein;

FIG. 1B shows an example of elements of a dual-camera in a perspective view;

FIG. 2 shows schematically a use case of the system of FIG. 1A;

FIG. 3 shows a flow chart of a method in the use case of FIG. 2;

FIG. 4A shows another embodiment of a system disclosed herein;

FIG. 4B shows yet another embodiment of a system disclosed herein;

FIG. 5 shows schematically a use case of the systems of FIGS. 4A or 4B;

FIG. 6A shows schematically a method of use of the systems in FIGS. 4A or 4B;

FIG. 6B shows schematically another method of use of the systems in FIGS. 4A or 4B;

FIG. 6C shows schematically yet another method of use of the systems in FIGS. 4A or 4B;

FIG. 7A shows yet another embodiment of a system disclosed herein;

FIG. 7B shows yet another embodiment of a system disclosed herein;

FIG. 8 shows a vehicle cabin section and use case of a system in FIG. 7A and 7B;

FIG. 9A shows schematically a method of use of the systems in FIGS. 7A;

FIG. 9B shows schematically another method of use of the systems in FIG. 7B;

FIG. 10A shows yet another embodiment of a system disclosed herein;

FIG. 10B shows the resolution of an image obtained with known digital zoom;

FIG. 10C shows the resolution of an image obtained with "optical" zoom using the system of FIG.10A.

DETAILED DESCRIPTION

FIG. 1A shows an embodiment of a system disclosed herein and numbered **100**. System **100** may be installed in, or attached to a vehicle **102**. System **100** includes a Tele camera **104**, a Wide camera **106** and a processing unit ("processor") **108**. The vehicle may be for example a car, a bus, a truck, a motorcycle, a coach or any type of know vehicle. Processing unit **108** may be a CPU, GPU, ASIC, FPGA, or any other processor capable of graphic analysis. When used in conjunction with a vehicle, a system like system **100** may also be referred to as "advanced driver assistant system" or ADAS.

The combination of Tele camera **104** and Wide camera **106** may be referred as "dual-camera" and is numbered **110**. FIG. 1B shows an example of elements of a dual-camera **110** in a perspective view. Wide camera **106** comprises a Wide sensor **132** and a Wide lens **134** with a Wide lens optical axis **136**. Wide sensor **132** is characterized by a Wide sensor active area size and a Wide sensor pixel size. Wide lens **134** is characterized by a Wide effective focal length (EFL) marked EFL_W. Optionally, in an embodiment, Wide lens **134** may have a fixed (constant) EFL_W. Optionally, the Wide lens may be fixed at a constant distance from Wide image sensor **132** (fixed focus). Optionally, Wide lens **134** may be coupled to a focusing mechanism (e.g. an autofocus (AF) mechanism) that can change the distance of Wide lens **134** from Wide image sensor **132**, thereby providing a non-fixed (variable) focus). The combination of Wide sensor area and EFL_W determines the Wide FOV (FOV_W). According to some examples, FOV_W may be 50-100 degrees

in the horizontal vehicle-facing direction.

Tele camera **104** comprises a Tele sensor **122** and a Tele lens **124** with a Tele lens optical axis **138**. Tele sensor **122** is characterized by a Tele sensor active area size and a Tele sensor pixel size. Tele lens **124** is characterized by a Tele EFL, marked EFT_T. Optionally, in an embodiment, Tele lens **124** may have fixed (constant) EFL. In some embodiments, the Tele lens may be fixed at a constant distance from Tele image sensor **122** (fixed focus). Optionally, the Tele lens may be coupled to a focusing mechanism (e.g. an AF mechanism) that can change the distance of Tele lens **124** from Tele image sensor **122** (non-fixed focus). The combination of Tele sensor area and Tele lens EFL_T determines the Tele FOV (FOV_T). According to some examples, FOV_T may be between 10-30 degrees in the horizontal vehicle-facing direction. Thus, FOV_T is smaller (narrower) than FOV_W.

Tele camera **104** further comprises an OPFE **126**, e.g. a mirror or a prism. OPFE **126** has a reflection surface tilted by 45 degrees at a rest point from the Tele lens optical axis **138**. Tele camera **104** further comprises an actuator (motor) **128**. Actuator **128** may tilt the reflecting surface of OPFE **126** by up to $\pm \alpha$ degrees from the rest point (where exemplary α may be up to 10, 20, 40 or 70 degrees). That is, actuator **128** may tilt or scan the OPFE and with it FOV_T. Actuator **128** may be for example a stepper motor, or a voice coil motor (VCM) as described for example in co-owned patent application PCT/IB2017/057706.

In some examples, Wide camera **106** and Tele camera **104** face a vehicle front side and share at least some of their respective FOVs. Typically, FOV_W is directed away from the vehicle toward the front direction (driving direction) and is substantially symmetrical vs. the two sides of the vehicle. In one operational mode, the Tele camera is operational to scan the Tele FOV (FOV_T) inside the Wide FOV (FOV_W) using actuator **128**. In some examples, the scanning of FOV_T is for bringing the Tele camera to view more closely a detected potential object-of-interest (OOI), detected previously from Wide and/or Tele images, see in more detail below.

FIG. 2 shows schematically a use case of the system **100** of FIG. 1A. A dual-camera **110** is installed in a front part of a vehicle **102**. For example, a triangle **204** represents FOV_W in a horizontal plane, i.e. as a horizontal FOV_W or "$HFVO_W$". In FOV_W, an "observation distance" **206** is defined as the maximal distance that allows system **100** using an image from the Wide camera to detect a potential OOI. "OOI" may be for example a hazard, another vehicle, a hole or obstruction on a road, a pedestrian, a road curve, a road sign, etc.. An "identification distance" **208**

is defined as the minimal distance that allows system **100** using an image from the Wide camera to identify all the required information for making a decision, as known in the art. According to one example, the OOI may be a road sign observable but not readable in the observation distance. According to an example, an OOI may be observed in the observation distance, but identification or distinction between it being a road sign or a pedestrian is made only within the identification distance. In other words, if an OOI is located before (closer to the Wide camera than) the observation distance **206** but further than the identification distance **208**, then system **100** may use an image from the Wide camera to calculate that the OOI is located in FOV_W, but not to fully calculate required measures-of-action or response needed (see next).

According to some examples, measures-of-action or responses of system **100** may include one or more or a combination of the following: changing vehicle **102** speed and/or course, operating an internal alarm to the vehicle driver, operating an external alarm, sending data information to, or calling Internet/cloud based service/ police / road assistance services, etc. For example, a triangle **210** represents FOV_T in a horizontal plane, i.e. as a horizontal FVO_T ($HFVO_T$). According to one example, $HFOV_W$ may be in the range of 70-180 degrees and $HFOV_T$ may be in the range of 15-45 degrees. According to another example, $HFOV_W$ may be in the range of 140-180 degrees and $HFOV_T$ may be in the range of 15-70 degrees. Thus, the output images of the Tele camera may have higher resolution than the output images of the Wide camera. For example, the output image of the Tele camera may have 3 to 20 times more resolution than the output image of the Wide camera, and consequently identification distance **212** of the Tele camera may be 3 to 20 times further away than identification distance **208** of the Tele camera.

In an example shown in (a) of FIG. 2, vehicle **102** approaches OOI **202**. OOI **202** is located between observation distance **206** and identification distance **208**. While OOI **202** is observable by the Wide camera, it may not identifiable (namely the Wide camera captures OOI **202** with too low a resolution to identify, classify or handle, relative to the required by system **100**). As shown in FIG. 2(b), POV_T is then scanned to face OOI **202** such that the Tele camera may capture OOI **202** with more detail (e.g. "identify" it).

FIG. 3 shows a detailed flow chart of a method of operation of system **100** as in the example of FIG. 2:

Step **302**: Exemplarily, the Wide camera (e.g. **106**) acquires Wide images. In some alternative embodiments, images may also or optionally be acquired by the Tele camera.

Step 304: Exemplarily, the Wide camera sends Wide images acquired in step **302** to a processing unit (e.g. **108**) for analysis. In some alternative embodiments, Tele images acquired in step **302** may also or optionally be to sent to the processing unit for analysis.

Step **306**: The processing unit detects the existence of OOI **202** in front of vehicle **102**, but requires more details to address or decide on a course of action.

Step **308**: The processing unit directs the Tele camera (e.g. **104**) to have FOV_T face OOI **202** (i.e. by scanning the Tele camera), thereby acquiring and receiving images of OOI **202** with higher quality and/or higher resolution. The processing unit may then have more information on the OOI in order to fully calculate required measures-of-action or response needed.

In some examples, the Tele camera may be a camera equipped with a motor to drive the entire camera. In some examples, the Tele camera may be a folded camera as described in co-owned patent application PCT/IB2016/057366, in which the OPFE is operational to change (i.e. scan) a Tele camera point of view (POV). In some examples, the Tele camera may scan in one dimension (1D) only (i.e. along a line). In some examples, the Tele camera may scan in two dimensions (2D), namely scan an area. In some examples, the motor for scanning may be a VCM, a shape memory alloy (SMA) motor, a piezoelectric motor, a stepper motor or a DC motor. In some examples, the Tele camera and/or the Wide camera may be integrated with optical image stabilization (OIS) to compensate on vehicle vibrations.

FIG. 4A shows an embodiment of a system numbered **400** installed in, or attached to a vehicle **402**. Optionally, vehicle **402** may have a steering wheel **416**. In some vehicles, handlebars (not shown) may replace a steering wheel, with the following description being relevant to both. In contrast with system **100**, system **400** comprises only a Tele camera **404** (similar to Tele camera **102**) and a processing unit **408** (similar to processing unit **108).**

FIG. 4B shows an embodiment of another system numbered **400'**, similar to system **100** i.e. comprising a Wide camera **406** in addition to Tele camera **404**. The description below refers to systems **400** and **400'**. The Tele camera faces the vehicle front side. As seen in FIG. 5, in system **400**, Tele camera **404** is operational to change angle / direction of POV_T as marked by an arrow **502**, thereby achieving an "effective" FOV marked FOV_E, which is larger than FOV_T. According to one optional use case of system **400** (FIG. 6A), a processing unit constantly commands the Tele camera to continually change the POV direction or angle from left to right and vice-versa (**602**), and the Tele camera rotates according to the commands received (**604**). In a second optional use

case of system **400** (FIG. 6B), the processing unit follows the steering wheel or handle bars: when the user turns the steering wheel/handle bar to the left (**612**), the Tele camera POV (POV_T) moves to the left, and when the user turns the steering wheel/handle bar to the right, POV_T moves to the right. According to a third optional use case of system **400** (FIG. 6C), the processing unit may use image recognition algorithm to identify road curves and change FOV_T to follow the road.

FIG. 7A shows another shows an embodiment of another system numbered **700** (similar e.g. to system **400**) that may be installed in, or attached to a vehicle **702**. Vehicle **702** comprises a vehicle cabin **716**.

FIG. 7B shows an embodiment of yet another system numbered **700'**, similar to system **100** and including a Wide camera **706** (like camera **106**) in addition to Tele camera **704**. Wide camera **706** may also be installed in vehicle cabin **716** to face OOI **802**.

FIG. 8 shows a vehicle cabin section and use case of a system in FIG. 7A and 7B. Wide camera **706** is not shown. Tele camera **704** with FOV_T faces the interior of vehicle cabin **716** and an OOI **802**, for example a passenger. Tele camera **704** may be scanned to allow the effective FOV (FOV_E) larger than FOV_T.

FIG. 9A shows in a flow chart main steps of a method of use of system **700.** Tele camera **704** is operational to change angle / direction and scan vehicle cabin **716**. Processing unit **708** is operational to identify an OOI **802** (e.g. passenger body, face, eyes, etc.). Processing unit **708** is further operational to direct Tele camera **704** to face OOI **802**. The data obtained by the Tele camera is used for identifying hazards (e.g. driver not looking at the road, driver falling asleep, passengers without seatbelts, a child without a child seat, etc.). FIG. 9B shows in a flow chart main steps of a method of use of system **700'**. The processing unit uses data from both Wide and Tele cameras to direct the Tele camera to OOI **802**.

FIG. 10A shows an embodiment of yet another system disclosed herein and numbered **1000**. System **1000** comprises a Tele camera **1002**, a Wide camera **1004** and a processing unit **1006** and may be used for surveillance, thus being also named "surveillance camera". Tele camera **1002** and Wide camera **1004** are part of a dual-camera **1010**. These components may be similar to or even identical with Wide and Tele cameras and processors described in embodiments above. Surveillance camera **1000** and processing unit **1006** may include software and algorithms to detect OOIs (for example human faces) in FOV_W and to steer the Tele camera in X and Y directions in Wide images to these OOIs to enhance the image or video quality of these objects and to enable

their analysis (e.g. for face recognition in the case where the object is a face).

In an embodiment, processing unit **1006** may instruct Tele camera **1002** to continuously scan parts of FOV_W. In an embodiment, processing unit **1006** may instruct Tele camera **1002** to move to a specific location (as in FIG. 9). The tilting and settling time of the prism may occur in 5-50msec. Further, Tele camera **1002** may switch from pointing from one region of interest (ROI) to another every 1sec, or at a faster or slower pace. FIG. 10B shows an example of an imaged scene acquired by Wide camera **1004** and then digitally zoomed, and FIG. 10C shows an example of an imaged scene acquired by Wide camera **1004** (left side) and then by a directed Tele camera **1002** to optically zoom on the ROI (right side). The zoomed image in FIG. 10C shows significant resolution gain over the digitally zoomed image in FIG. 10B, allowing for example facial recognition of people in the ROI.

Wide and Tele images and/or video streams may be recorded during automatic tracking mode and may be fused together to form a composite image or a composite video stream, as known in the art. This fusion may be applied on a camera hosting device (e.g. a mobile electronic device of any type that includes a a system or camera disclosed herein). Alternatively, Wide and Tele images or video streams may be uploaded to the cloud for applying this fusion operation. Each composite image may also have the same FOV, by scanning with the Tele camera, stitching a plurality of Tele images to provide a "stitched" Tele image, then fusing the stitched Tele image with a Wide image. This is advantageous in that the Wide image captures the entire scene simultaneously, while the Tele images to be stitched together are consecutive, so one can overcome motion or occlusions in the scene if required. The stitching of the Tele images and/or the fusion of the stitched Tele image with the Wide image may also be performed in a cloud.

While this disclosure has been described in terms of certain embodiments and generally associated methods, alterations and permutations of the embodiments and methods will be apparent to those skilled in the art. The disclosure is to be understood as not limited by the specific embodiments described herein, but only by the scope of the appended claims.

WHAT IS CLAIMED IS:

1. A system, comprising:

a) a Wide camera with a Wide field of view FOV_W and comprising a Wide sensor and a Wide lens, wherein the Wide camera is operative to output Wide image information;

b) a Tele camera with a Tele field of view FOV_T smaller than FOV_W and comprising a Tele sensor, a Tele lens with a Tele lens optical axis and a scanning optical path folding element (OPFE); and

c) a processing unit operative to detect an object of interest (OOI) from Wide and/or Tele image information and to direct the Tele camera to move the FOV_T to acquire Tele image information on the OOI.

2. The system of claim 1, wherein the system is installed in a vehicle and wherein the processing unit is further operative to calculate a required measure-of-action or response needed from the vehicle.

3. The system of claim 2, further comprising an actuator to tilt the OPFE to move or scan the FOV_T.

4. The system of claim 2, wherein the processing unit is operative to direct the Tele camera to move the FOV_T to substantially a center of the FOV_W.

5. The system of claim 2, wherein the processing unit is operative to direct the Tele camera to move the FOV_T to substantially a center of the OOI.

6. The system of claim 2, wherein the processing unit is operative to receive steering information from a steering wheel of the vehicle and to direct the Tele camera to move or scan the FOV_T based also on the steering information.

7. The system of claim 3, wherein the processing unit is operative to receive steering information from a steering wheel of the vehicle and wherein the actuator tilts the OPFE to move

or scan the FOV_T based also on the steering information.

8. The system of claim 2, wherein the FOV_W covers a road in front of the vehicle, wherein the OOI is a road curve and wherein the processing unit is operative to move the FOV_T to follow the road curve.

9. The system of claim 2, wherein the vehicle comprises a vehicle cabin, wherein the OOI is located inside the vehicle cabin and wherein the OPFE may be tilted to provide an extended Tele camera FOV (FOV_E) greater than FOV_T.

10. The system of claim 2, wherein the OOI is a driver of the vehicle and wherein the required measure-of-action or response is based on a gaze of the driver.

11. The system of claim 2, wherein the OOI is a child and wherein the required measure-of-action or response is a warning that the child does not wear a seat belt.

12. The system of claim 2, wherein the required measure-of-action or response includes a measure-of-action or response selected form the group consisting of changing speed and/or course of the vehicle, operating an internal alarm to a driver of the vehicle, operating an external alarm, sending data information to, or calling Internet/cloud based service/ police / road assistance services, and a combination thereof.

13. The system of claim 1, wherein the OOI is a human face.

14. The system of claim 13, wherein the processing unit is operative to instruct the Tele camera to move to a specific location of the human face for face recognition.

15. The system of claim 13, wherein the processing unit is operative to instruct the Tele camera to move FOV_T to scan parts of FOV_W in two directions.

16. The system of claim 15, wherein the scan is performed by the scanning OPFE with a tilting and settling time of the OPFE of between 5-50msec.

17. The system of claim 1, wherein the processing unit is operative to detect the OOI from Wide and/or Tele image information and to direct the Tele camera to move FOV_T to acquire information on the OOI in automatic tracking mode.

18. The system of claim 1, wherein the Wide and Tele image information may be fused together to form a composite image or a composite video stream.

19. The system of claim 18, wherein each composite image has the same field of view.

20. The system of claim 19, wherein a composite image is formed by stitching a plurality of Tele images.

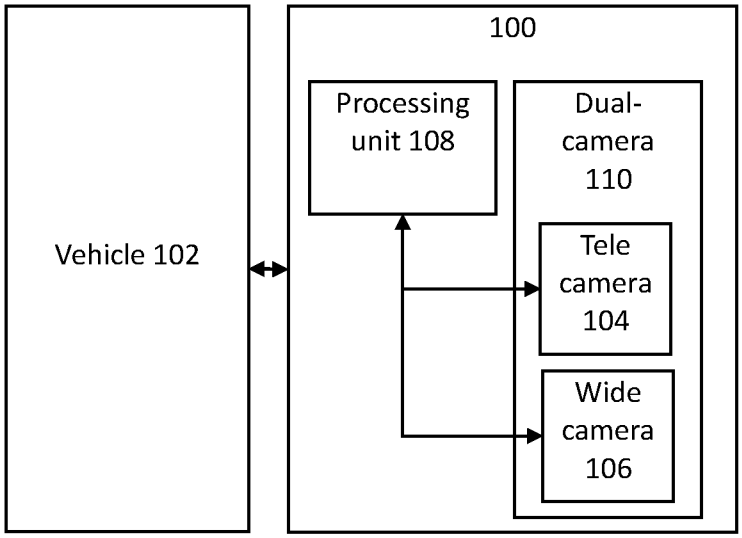

100
Vehicle 102
Processing unit 108
Dual-camera 110
Tele camera 104
Wide camera 106

FIG. 1A

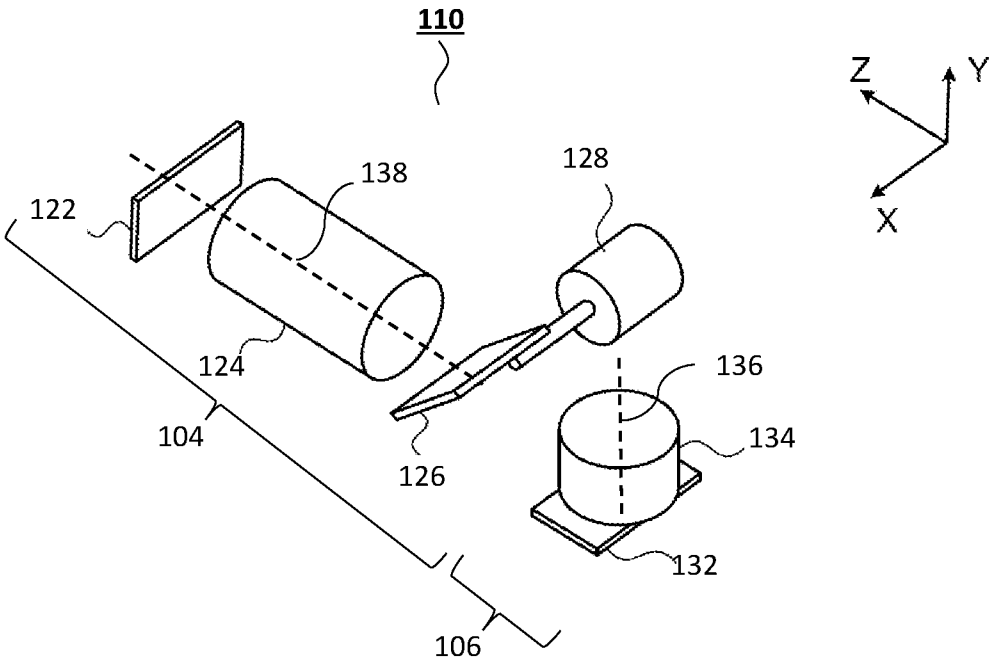

110
Z
Y
X
122
138
128
124
136
104
134
126
132
106

FIG. 1B

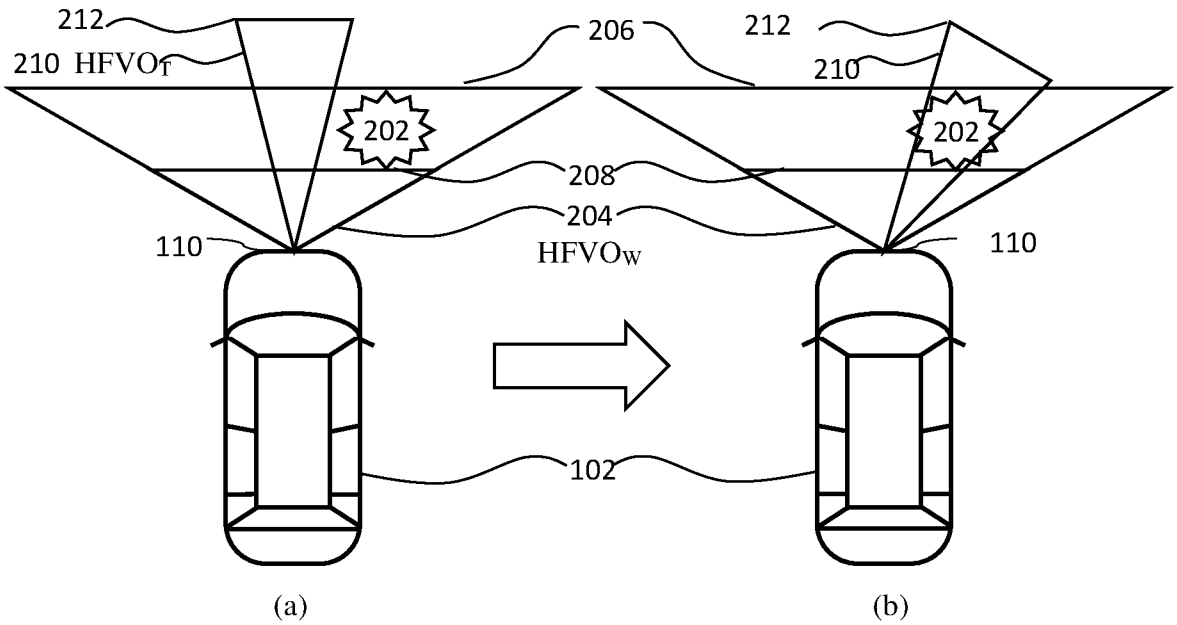

212
210 HFVOT
206
212
210
202
202
208
204
HFVOW
110
110
102
(a)
(b)

FIG. 2

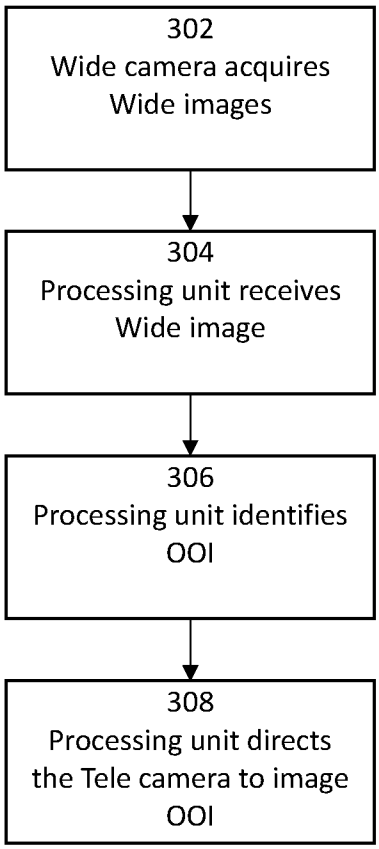

302
Wide camera acquires Wide images
304
Processing unit receives Wide image
306
Processing unit identifies OOI
308
Processing unit directs the Tele camera to image OOI

FIG. 3

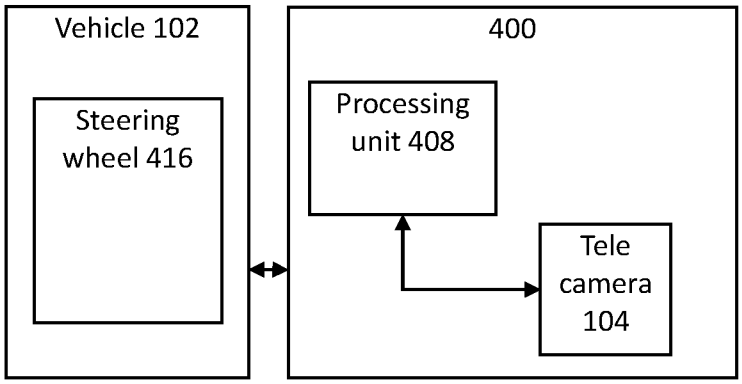

Vehicle 102
Steering wheel 416
400
Processing unit 408
Tele camera 104

FIG. 4A

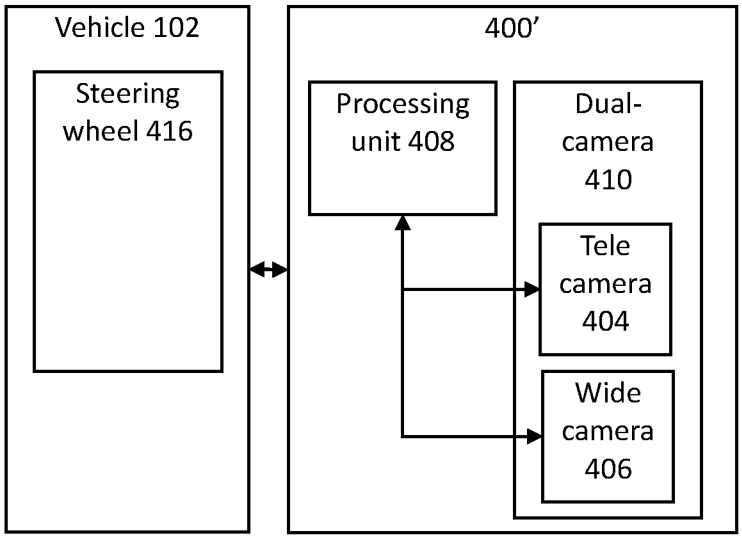

Vehicle 102
Steering wheel 416
400'
Processing unit 408
Dual-camera 410
Tele camera 404
Wide camera 406

FIG. 4B

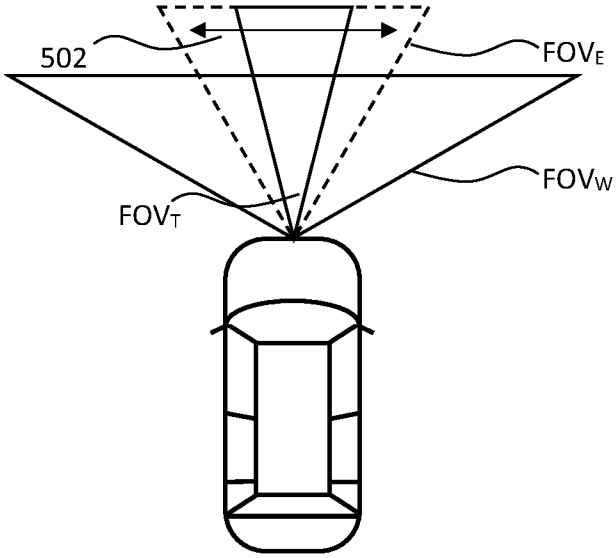

502
FOV_E
FOV_W
FOV_T

FIG. 5

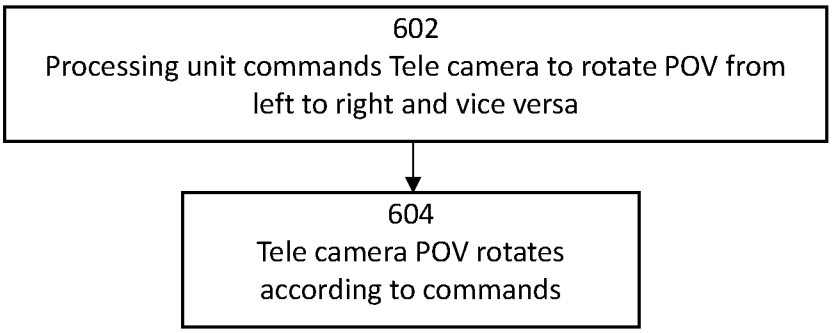

602
Processing unit commands Tele camera to rotate POV from left to right and vice versa
604
Tele camera POV rotates according to commands

FIG. 6A

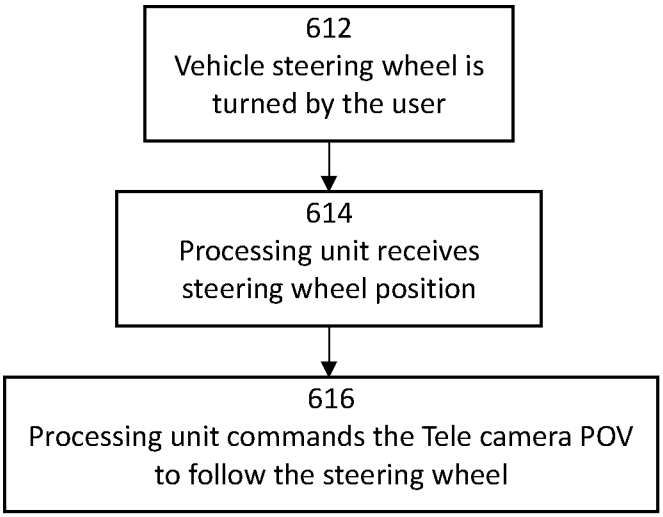

612
Vehicle steering wheel is turned by the user
614
Processing unit receives steering wheel position
616
Processing unit commands the Tele camera POV to follow the steering wheel

FIG. 6B

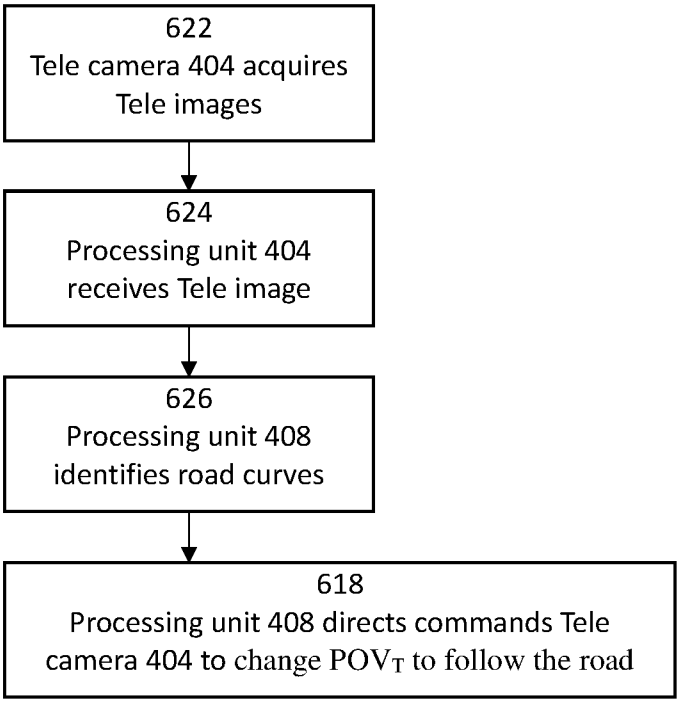

622
Tele camera 404 acquires Tele images
624
Processing unit 404 receives Tele image
626
Processing unit 408 identifies road curves
618
Processing unit 408 directs commands Tele camera 404 to change POV_T to follow the road

FIG. 6C

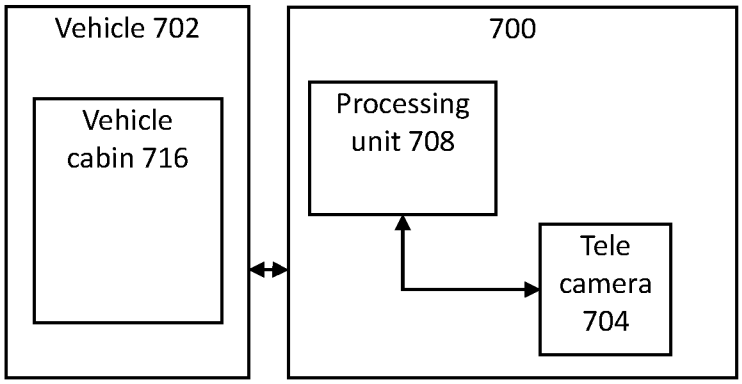

Vehicle 702
Vehicle cabin 716
700
Processing unit 708
Tele camera 704

FIG. 7A

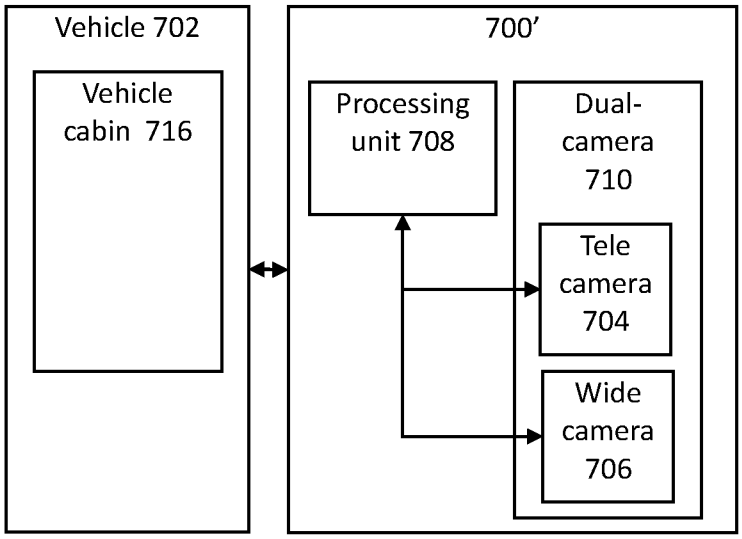

Vehicle 702
Vehicle cabin 716
700'
Processing unit 708
Dual-camera 710
Tele camera 704
Wide camera 706

FIG. 7B

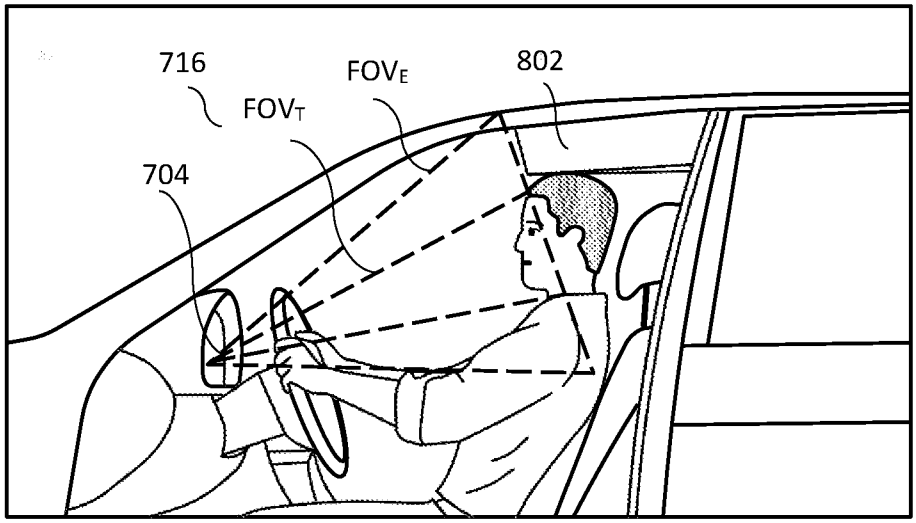

716
FOV$_T$
FOV$_E$
802
704

FIG. 8

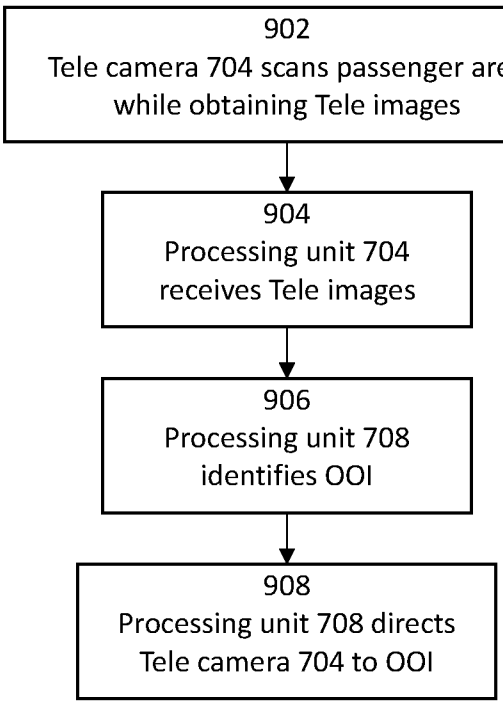

902
Tele camera 704 scans passenger area while obtaining Tele images
904
Processing unit 704 receives Tele images
906
Processing unit 708 identifies OOI
908
Processing unit 708 directs Tele camera 704 to OOI

FIG. 9A

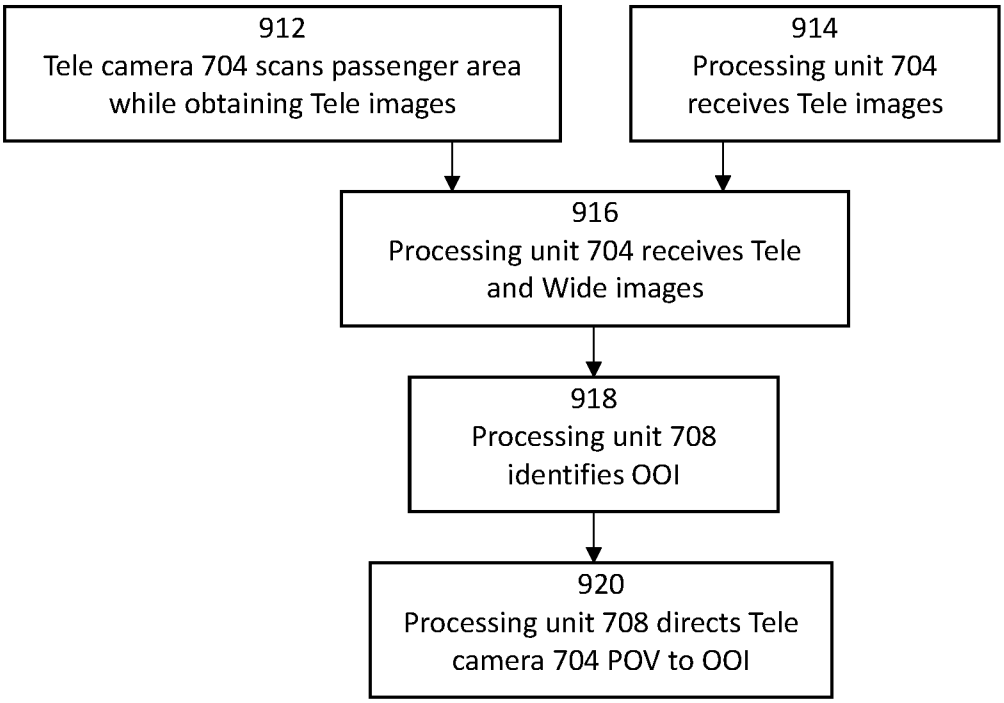


FIG. 9B

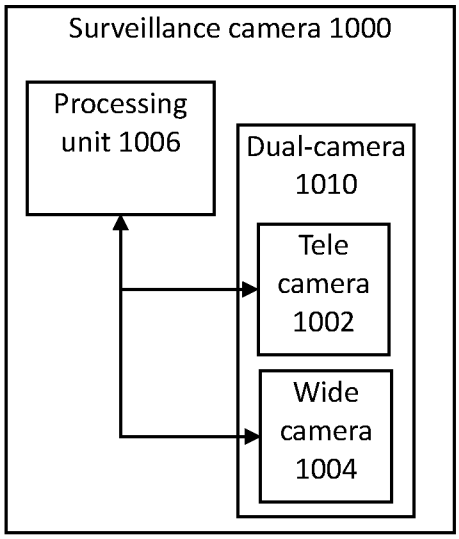
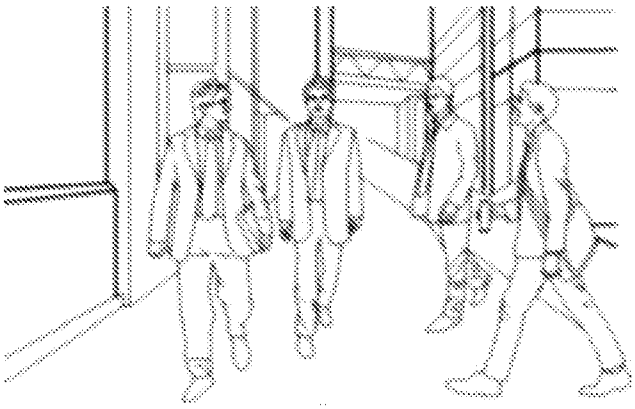
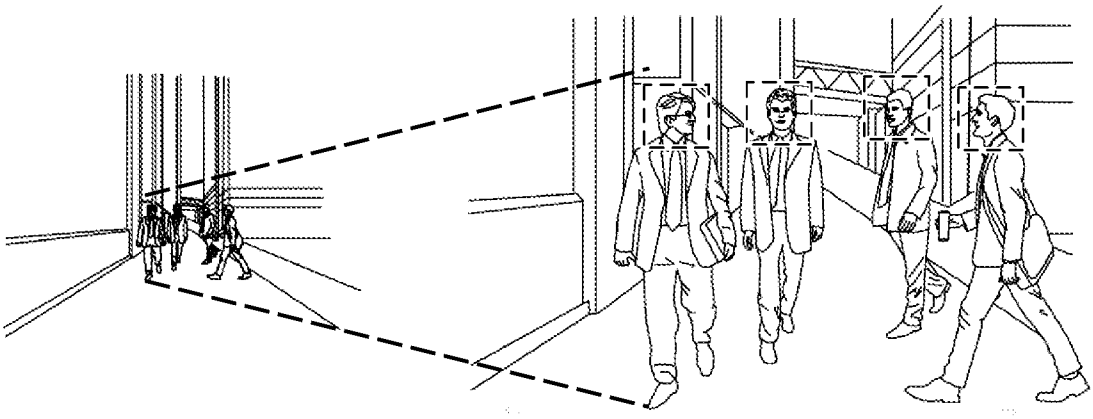


FIG. 10A



Digital Zoom

FIG. 10B



Optical Zoom by Tele camera

FIG. 10C