METHOD AND APPARATUS FOR GENERATING A PLAN-VIEW IMAGE OF A LOCATION BASED ON AN IMAGE OF AN OBJECT AT THE LOCATION

FIELD OF INVENTION

[0001] The present invention relates broadly, but not exclusively, to a method and an apparatus for generating a plan-view image of a location based on an image of an object at the location.

BACKGROUND

[0002] There has been a growing trend towards the use of cameras in various sectors for use of facilities that require minimum human interaction. In the context of drive-through lanes, for example, cameras are used to estimate a position of a vehicle relative to a self-service kiosk. A plan-view of the drive-through lane, for example, may provide an estimation of the position of the vehicles.

[0003] The technical problem arises due to building constraints and other physical limitations that may make it difficult to install cameras at an optimal height and angle to capture a plan-view of a location. Further, conventional techniques such as use of checkerboard patterns require capturing different views of a location at varying angles and distances to manually calibrate a camera to analyse spatial distribution of objects at a location. Such convention techniques, however, may not be viable for all locations as the conventional techniques require images taken at varying angles, which may not be possible due to building constraints and other physical limitations. A solution is therefore needed to generate a plan-view image of a location, based on images taken from a non-plan view image to effectively capture the spatial distribution of objects at a location, without being limited by physical constraints.

[0004] Herein disclosed are embodiments of a method and apparatus for generating a plan-view image of a location based on an image of an object at the location.

[0005] Furthermore, other desirable features and characteristics will become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and this background of the disclosure.

SUMMARY

[0006] In one aspect, the present disclosure refers to a method for generating a plan-view image of a location based on an image of an object at the location, comprising determining a first coordinate in a first image, the first coordinate associated with a first pair of components detected in the first image capturing the object at a first position at the location , wherein a component of the first pair of components is positioned at a first side of the object and a further component of the first pair of components is positioned at a second side of the object that is opposite the first side, determining a second coordinate in a second image, the second coordinate associated with the first pair of components detected in the second image capturing the object at a second position at the location, the first image and the second image being captured via a sensor device that is disposed to capture a non-plan view image of the location, and generating, by the processor, the plan-view image of the location based on a comparison between the first coordinate and the second coordinate.

[0007] In another aspect, the present disclosure refers to an apparatus for generating a plan-view image of a location based on an image of an object at the location, comprising at least one processor, and at least one memory including computer program code; the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to determine a first coordinate in a first image, the first coordinate associated with a first pair of components detected in the first image capturing the object at a first position at the location, wherein a component of the first pair of components is positioned at a first side of the object and a further component of the first pair of components is positioned at a second side of the object that is opposite the first side, determine a second coordinate in a second image, the second coordinate associated with the first pair of components detected in the second image capturing the object at a second position at the location, the first image and the second image being captured via a sensor device that is disposed to capture a non-plan view image of the location, and generate the plan-view image of the location based on a comparison between the first coordinate and the second coordinate.

[0008] Additional benefits and advantages of the disclosed embodiments will become apparent from the specification and drawings. The benefits and/or advantages may be individually obtained by the various embodiments and features of the specification and drawings, which need not all be provided in order to obtain one or more of such benefits and/or advantages.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The accompanying Figures, where like reference numerals refer to identical or functionally similar elements throughout the separate views and which together with the detailed description below are incorporated in and form part of the specification, serve to illustrate various embodiments and to explain various principles and advantages in accordance with a present embodiment, by way of non-limiting example only.

[0010] Embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

[0011] Figure 1 shows an exemplary illustration of a vehicle in a drive-thru lane.

[0012] Figure 2 shows an exemplary illustration of a solution implemented by a conventional technique.

[0013] Figure 3 shows a flowchart illustrating a method for generating a plan-view of a location based on an image of an object at the location according to an embodiment of the present disclosure.

[0014] Figure 4 shows an exemplary illustration of a method for detecting vehicle components according to an embodiment of the present disclosure.

[0015] Figure 5 shows an exemplary illustration of a plan view image generated based on images of vehicles at drive-through lanes according to an embodiment of the present disclosure.

[0016] Figure 6 shows another exemplary illustration of a plan view image generated based on images of vehicles at drive-through lanes according to an embodiment of the present disclosure.

[0017] Figure 7 shows an exemplary illustration of an implementation of the present disclosure.

[0018] Figure 8 shows an exemplary illustration of another implementation of the present disclosure.

[0019] Figure 9 shows an exemplary illustration of yet another implementation of the present disclosure.

[0020] Figure 10 shows an exemplary illustration of yet another implementation of the present disclosure.

[0021] Figure 11 shows an exemplary illustration of yet another implementation of the present disclosure.

[0022] Figure 12 shows an exemplary illustration of yet another implementation of the present disclosure.

[0023] Figure 13A shows an exemplary illustration of a vehicle-end detection zone according to an embodiment of the present disclosure.

[0024] Figure 13B show an exemplary illustration of multi-transformation-regions according to an embodiment of the present disclosure.

[0025] Figure 14 shows an exemplary illustration of images of a vehicle captured at a location according to an embodiment of the present disclosure.

[0026] Figure 15 shows an exemplary illustration of detected components according to an embodiment of the present disclosure.

[0027] Figure 16 shows another exemplary illustration of detected vehicle components according to an embodiment of the present disclosure.

[0028] Figure 17 shows an exemplary illustration of a method for determining coordinates associated with pairs of components according to an embodiment of the present disclosure.

[0029] Figure 18 shows a flow chart of a process for generating a plan-view image of a location based on an image of an object at the location according to an embodiment of the present disclosure.

[0030] Figure 19 shows an exemplary illustration of images of a vehicle taken at different time instances according to an embodiment of the present disclosure.

[0031] Figure 20 shows an exemplary illustration of images of a vehicle captured at different positions according to an embodiment of the present disclosure.

[0032] Figure 21 shows a flowchart illustrating a method for detecting unevenness at a location according to an embodiment of the present disclosure.

[0033] Figure 22 shows an exemplary illustration of a method for calculating the centre points of detected pair of component in an image according to an embodiment of the present disclosure.

[0034] Figure 23 shows an exemplary illustration of vehicles on levelled and uneven grounds according to an embodiment of the present disclosure.

[0035] Figure 24 shows an exemplary illustration of a method for estimating a position of a missing component of an object according to an embodiment of the present disclosure.

[0036] Figure 25 shows an exemplary illustration of another method for estimating a position of a missing component of an object according to an embodiment of the present disclosure.

[0037] Figure 26 shows an exemplary illustration of a method for calculating a coordinate associated with a missing component according to an embodiment of the present disclosure.

[0038] Figure 27 shows an exemplary illustration of another method for calculating a coordinate associated with a missing component according to an embodiment of the present disclosure.

[0039] Figure 28 shows an exemplary illustration of yet another method for calculating a coordinate associated with a missing component according to an embodiment of the present disclosure.

[0040] Figure 29 shows an exemplary illustration of a method for generating a plan-view image according to an embodiment of the present disclosure.

[0041] Figure 30 shows another exemplary illustration of a method for generating a plan-view image according to an embodiment of the present disclosure.

[0042] Figure 31 shows a schematic diagram of an exemplary computing device suitable for use to execute the method in Figure 3.

[0043] Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been depicted to scale. For example, the scale of some of the elements in the illustrations, block diagrams or flow charts may be exaggerated in respect to other elements to help an accurate understanding of the present embodiments.

DETAILED DESCRIPTION

[0044] Embodiments of the present invention will be described, by way of example only, with reference to the drawings. Like reference numbers and characters in the drawings refer to like elements or equivalents.

[0045] Unless specifically stated otherwise, and as apparent from the following, it will be appreciated that throughout the present specification, discussions utilizing terms such as “estimating”, “calculating”, “determining”, “generating”, “retrieving”, “recognizing” or the like, refer to the action and processes of a computer system, or similar electronic device, that manipulates and transforms data represented as physical quantities within the computer system into other data similarly represented as physical quantities within the computer system or other information storage, transmission or display devices.

[0046] The present specification also discloses apparatus for performing the operations of the methods. Such apparatus may be specially constructed for the required purposes, or may comprise a computer or other device selectively activated or reconfigured by a computer program stored in the computer. The algorithms and displays presented herein are not inherently related to any particular computer or other apparatus. Various machines may be used with programs in accordance with the teachings herein. Alternatively, the construction of more specialized apparatus to perform the required method steps may be appropriate. The structure of a computer will appear from the description below.

[0047] In addition, the present specification also implicitly discloses a computer program, in that it would be apparent to the person skilled in the art that the individual steps of the method described herein may be put into effect by computer code. The computer program is not intended to be limited to any particular programming language and implementation thereof. It will be appreciated that a variety of programming languages and coding thereof may be used to implement the teachings of the disclosure contained herein. Moreover, the computer program is not intended to be limited to any particular control flow. There are many other variants of the computer program, which can use different control flows without departing from the spirit or scope of the invention.

[0048] Furthermore, one or more of the steps of the computer program may be performed in parallel rather than sequentially. Such a computer program may be stored on any computer readable medium. The computer readable medium may include storage devices such as magnetic or optical disks, memory chips, or other storage devices suitable for interfacing with a computer. The computer readable medium may also include a hard-wired medium such as exemplified in the Internet system, or wireless medium such as exemplified in the GSM mobile telephone system. The computer program when loaded and executed on such a computer effectively results in an apparatus that implements the steps of the preferred method.

Exemplary embodiments

[0049] Various embodiments of the present disclosure relate to a method and an apparatus for generating a plan-view image of a location based on an image of an object at the location.

[0050] A location may refer to one or more pathways, streets, lanes or places that may comprise of one or more objects. For example, a location such as a drive-through lane may comprise of objects such as vehicles or self-service kiosks. In an example, an image of a location may be captured by cameras, sensors or other similar imaging devices. The image may be a still image captured at a time instance. Alternatively, the image may be a video frame within a video stream, where the video frame represents visual data showing a position of an object at the location at a time instance. Alternatively, the image may be a static snapshot taken by a camera, sensor, or other similar imaging devices to capture a state of the location at a time instance. In an example, the image may be used to determine a position of an object at a location. A position of an object at a location may be construed as the position of the object in the image, wherein the position may be represented by a coordinate, comprising a horizontal (x) value and a vertical (y) value

relative to a horizontal axis and a vertical axis of the image. Additionally, a position of an object may be represented by one or more coordinates in the image. In an example, a plan-view image of a location may be generated based on two or more images of an object at the location. The two or more images may capture varying positions of the object at the location at a same camera angle at different time instances.

[0051] An image may refer to a still image or a video frame capturing a location at a time instance. The image may comprise multiple pixels and each pixel may be associated with a coordinate in the image, wherein the coordinate comprises of a horizontal (x) value and a vertical (y) value relative to a horizontal axis and a vertical axis of the image. A position of an object may be represented by one or more coordinates in the image. For example, a position of an object may be represented by one or more coordinates that are associated with one or more pixels representing the object in an image. In an example, an image of a location may be captured by cameras, sensors or other similar imaging devices. The image may be a still image captured at a time instance. Alternatively, the image may be a video frame within a video stream, where the video frame represents visual data showing a position of an object at the location at a time instance. Alternatively, the image may be a static snapshot taken by a camera, sensor, or other similar imaging devices to capture a state of the location at a time instance.

[0052] A coordinate may refer to a set of values that define a position of an object, a component or any points within an image, where each coordinate comprises of a horizontal (x) value and a vertical (y) value. The horizontal (x) value and the vertical (y) value may be values that are relative to a horizontal axis and a vertical axis of an image, respectively. In an example, a coordinate may be a mid-point between a component of a pair of components and a further component of the pair of components, and the coordinate may be determined based on coordinates representing the positions of the component and the further component. In a further example, a coordinate (e.g., a midpoint) may be determined for each of one or more pairs of components. It should be appreciated that a coordinate herein may be any coordinate that may be used to determine or represent a position of an object based on a horizontal axis and a vertical axis relative to the image.

[0053] A "component" may refer to a part of an object that may be detected in an image. Two components may form a pair of components of an object. A component of the pair of components may be at a first side of the object, and a further component of the pair of components may be at a second side of the object that is opposite the first side. A

position of a component in an image may be represented by one or more coordinates, which may be associated with pixels representing the component in the image. One or more components may be identified by a sensor, a camera, or other detection device, and a position of each of the one or more identified components in an image may be used to determine one or more coordinates that may be used for generating a plan-view image of a location. Additionally, a component may also be a part of an object such as a vehicle, where the pair of components (e.g., side mirrors or fog lights) may be detected in images taken at different time instances or angles.

[0054] A position may refer to where an object at a location is detected in an image. The position may be represented by one or more coordinates that are associated with one or more pixels representing the object in the image. In an example, a position may be referred to as a first position, second position and follow other similar ordering conventions. Additionally, a position of an object may be represented by one or more coordinates that are associated with one or more pixels representing the object in an image. Similarly, a position of a component may be represented by one or more coordinates that are associated with one or more pixels representing the component in the image.

[0055] An object may refer to an entity, a being, a moving vehicle, or any matter that may be captured in an image. A position of an object may be represented by a coordinate in the image, for example comprising a horizontal (x) value and a vertical (y) value relative to a horizontal axis and a vertical axis of the image. Additionally, an object may comprise of one or more pairs of components that may be similar in shape. A component of the pair of components may be at a first side of the object, and a further component of the pair of components may be at a second side of the object that is opposite the first side. The pair of components of the object may be captured in an image by cameras, sensors or other similar devices. Additionally, a position of a component may be construed as one or more coordinates that are associated with one or more pixels representing the component in an image. In an example, positions associated with the components in a first image capturing the vehicle at a first position may be used to determine a first coordinate associated with the pair of components. For example, the first coordinate may be a coordinate that is a mid-point between a coordinate associated with a position of a component and a further coordinate associated with a further component, wherein the component and the further component are components belonging to the pair of components. Alternatively, positions associated with the component in a second image capturing the vehicle at a second position may be used

to determine a second coordinate associated with the pair of components. The first image and the second image may be images of the object captured at a first position and a second position, respectively. Additionally, the first image and the second image may be captured at different time instances. It will be appreciated that further images may be captured, and similar naming conventions will follow throughout the description. For example, a third image may be an image captured at a third time instance. Further, an image may capture one or more objects at a location, and each object may comprise of one or more pairs of components.

[0056] A plan-view may refer to a top-down view of a location or an object. A plan-view of a location may be used to show a spatial distribution of objects at a location. A plan view may refer to a top-down view that may capture an object or a location from above, showing a spatial distribution of the object at the location, such that a position of the object may be estimated at the location. It should be noted that an image (e.g., first image, second image or the like) may refer to the image capturing an object at a location at a same camera angle. The image may also capture a plan-view of the object at the location, and a plurality of such images at the same camera angle may be used to generate a plan-view image of the object at the location. Additionally, any other view that may not show a plane view of a location, may be referred to herein as a non-plan view.

[0057] Figure 1 shows an exemplary illustration 100 of a vehicle in a drive-through lane according to an embodiment of the present disclosure. The illustration shows a vehicle 102 and a self-service kiosk 104 that is observable from different camera views, comprising of a frontal view, plan-view and a side view.

[0058] There has been a growing trend towards the use of self-service kiosks in various sectors, driven by advancements in artificial intelligence (AI). These AI-powered kiosks offer customers a convenient and efficient way to place orders, make payments, and receive services without the need for human interaction. For example, AI-powered kiosks may be integrated into fast food drive-thru lanes and automated toll booths to facilitate interaction between a driver and a kiosk.

[0059] Generating a plan-view image of locations such as drive-through lanes and automated toll booths based on images taken from a non-plan view is essential to determine the spatial distributions of objects such as vehicles, lanes and kiosks at the drive-through lane. However, challenges arise due to variation in camera views of the drive through lane. For example, as vehicles move towards or away from the kiosk, the

distance between the camera and the vehicle changes, leading to inconsistent image scales. This variability hampers the ability to correctly identify a location of the vehicle relative to the kiosk or other areas of interest. This variability may also affect features like facial recognition and gesture detection in self- service kiosks. Therefore, analysing spatial distribution of the vehicles through a plan-view of the drive through lane may facilitate the use of services within the drive-through lane,

[0060] Referring to illustration 100 of Figure 1, it may be observed that the plan-view and the side view shows a clearer estimation of the vehicle's position relative to the kiosk, whereas the frontal view does not clearly show a distance between the vehicle and the kiosk. Indeed, spatial distribution of the vehicles and the kiosks are better observed in the plan-view and side-view cameras. A plan-view camera setup offers a better solution to inconsistent measurements by capturing images from above. However, side or front camera views are more commonly used for real-world operation as implementing a plan-view camera in drive-thru kiosks may face challenges due to building constraints that make it difficult to install cameras at the optimal height and angle. If a plan-view camera is positioned too low, for example, the camera might not capture the entire area effectively, limiting its monitoring capabilities.

[0061] Figures 2 shows an exemplary illustration 200 of a solution implemented by a conventional technique. Utilising a checkerboard patten 202 is one of the most common and effective method for camera calibration, enabling reliable real-world understanding for various computer vision applications. The checkerboard patten's grid structure provides a uniform geometry with consistent spacing between detected points, which is crucial for accurately determining the camera's lens distortion and other intrinsic properties. By combining images from multiple angles and distances, one can gather a diverse set of data points that help in precisely calculating the camera's extrinsic parameters and understanding its spatial relationship with the environment. However, this method requires significant human labour, involving positioning the checkerboard at various angles and distances and capturing multiple images. Such convention techniques, however, may not be viable for all locations as the conventional techniques require images taken at varying angles, which may not be possible due to building constraints and other physical limitations. A solution is therefore needed to generate a plan-view image of a location, based on images taken from a non-plan view image to effectively capture spatial distribution of objects in the location, without being limited by physical constraints

[0062] Figure 3 shows a flowchart illustrating a method for generating a plan-view of a location based on an image of an object at the location according to an embodiment of the present disclosure.

[0063] The method starts with step 302 by determining a first coordinate in a first image, the first coordinate associated with a first pair of components detected in the first image capturing the object at a first position at the location, wherein a component of the first pair of components is positioned at a first side of the object and a further component of the first pair of components is positioned at a second side of the object that is opposite the first side.

[0064] A position of an object may be represented by one or more coordinates in the image. For example, a position of an object may be represented by one or more coordinates that are associated with one or more pixels representing the object in the image.

[0065] In step 304, the method proceeds determining a second coordinate in a second image, the second coordinate associated with the first pair of components detected in the second image capturing the object at a second position at the location, the first image and the second image being captured via a sensor device that is disposed to capture a non-plan view image of the location.

[0066] In step 306, the method proceeds to generating the plan-view image of the location based on a comparison between the first coordinate and the second coordinate.

[0067] In an embodiment, determining the first coordinate in the first image may further comprise determining the first coordinate to be a mid-point between the component of the first pair of components and the further component of the first pair of components in the first image capturing the object at the first position at the location.

[0068] In another embodiment, generating the image of the location further comprise determining whether or not a second pair of components of the object is detected in the first image capturing the object at the first position at the location, determining whether or not the first pair of components is positioned lower than the second pair of components in the first image, and generating the plan-view image of the location

based on a comparison of the first coordinate in the first image and the second coordinate in the second image, based on a result of the determination of whether or not the first pair of components is positioned lower than the second pair of components in the first image.

[0069] In yet another embodiment, generating the plan-view image of the location may further comprise, determining whether or not the first pair of components can be detected in the second image capturing the object at the second position at the location, determining a third coordinate associated with the first pair of components detected in a third image capturing the object at a third position at the location based on a result of the determination of whether or not the first pair of components can be detected in the second image, the third image being captured via the sensor device, and generating the plan view image of the location based on a comparison of the first coordinate in the first image and the third coordinate in the third image.

[0070] In yet another embodiment, determining the first coordinate in the first image may further comprise determining a position of the component of the pair of components in the first image capturing the object at the first position at the location, determining a length of the object in the first image, and estimating a position of the further component of the pair of components based on the position of the component of the pair of components and the length of the object.

[0071] In yet another embodiment, generating the plan-view image of the location may further comprise determining whether or not the second position of the object in the second image capturing the object at a second position at the location is within a predefined region of the second image, determining a third coordinate associated with the first pair of components detected in a third image capturing the object at a third position at the location based on a result of the determination of whether or not the second position of the object in the second image is within the predefined region of the second image, the third image being captured via the sensor device, and generating the plan-view image of the location based on a comparison of the first coordinate in the first image and the third coordinate in the third image.

[0072] In yet another embodiment, generating the plan-view image of the location may further comprise, calculating a number of pixels between a first centre point of the object at the first position and a second centre point of the object at the second position, determining whether or not the number of pixels is lower than a threshold

value, determining a third coordinate associated with the first pair of components detected in a third image capturing the object at a third position at the location based on a result of the determination of whether or not the number of pixels is lower than the threshold value, the third image being captured via the sensor device, and generating the plan view image of the location based on a comparison of the first coordinate in the first image and the third coordinate in the third image based on a result of the determination of whether or not the number of pixels is lower than the threshold value.

[0073]

[0074] Figure 4 shows an exemplary illustration 400 of a method for detecting vehicle components according to an embodiment of the present disclosure. First image 402 and a second image 404 shows an object (e.g., vehicle) captured by a camera 406 at a fixed angle. A processor in image analysis system may be used to detect pairs of components in the images (e.g., 402 and 404). In the context of vehicles, such pairs of components may comprise of, for example, fog lights, side mirrors or headlights that are similar in shape and serve a similar function. A component (e.g., headlight 408) of the pair of components may be at a first side of the vehicle, and a further component (e.g., headlight 410) of the pair of components may be at a second side of the object that is opposite the first side. The pair of components (e.g., 408 and 410) detected in the first image 402 and the second image 404 may be utilised by the image analysis system to perform the steps as described in descriptions accompanying Figure 3, to generate a plane view image as will be further described in descriptions accompanying Figures 19 - 24.

[0075] Figure 5 shows an exemplary illustration 500 of a plan view image generated based on images of vehicles at drive-through lanes according to an embodiment of the present disclosure. Based on a first image 402 and a second image 404 taken by the camera 406, a plan-view image 502 may be generated. The generation method will be further elaborated in descriptions accompanying Figure 28.

[0076] Figure 6 shows another exemplary illustration of a plan view image generated based on images of vehicles at drive-through lanes according to an embodiment of the present disclosure. In real-life scenarios, there may be one or more lanes with each lane dedicated for one vehicle. For example, image 602 shows two objects (e.g., vehicle) in lanes L1 and L2. Meanwhile, image 604 shows only one object (e.g., vehicle) in a single

lane L5. Multiple cameras (e.g., 606 and 608) may be used to capture the vehicles in the lanes. In an implementation of the present disclosure, a plan view image generated based on images captured by camera 606 and another plan view image generated based on images captured by the camera 608 may be combined together to form one plan-view image 610 capturing the lanes L1, L2 and L5.

[0077] Figure 7 shows an exemplary illustration 700 of an implementation of the present disclosure. As shown in Figure 7 of the present disclosure, a motion detector 702 may be used to determine if a vehicle is near a gate 704. Based on images captured by a camera that is mounted to the PIR (Passive Infrared) motion detector 702, a plan-view image may be showing the vehicle may be generated. Based on the generated plan-view image, the PIR motion detector 702 may be configured to send a signal to an event trigger module comprised in an external system (E.g., vehicle detection system, object detection system or the like). The Event Trigger Module then may be configured to send a signal to other IT computer system, triggering the gate 704 to open when the vehicle is within a predefined distance of the gate. In an example, such system may be commonly used in burglar alarms to automatically trigger smart device system and/or generate textual event message through message queue or Restful API for further IT-system integration.

[0078] Figure 8 shows an exemplary illustration 800 of another implementation of the present disclosure. A plan-view image generation system according to an embodiment of the present disclosure may be configured to use camera with a wide-angle lens with barrel distortion. The lens design may ensure that the distortion is symmetric, providing equal distortion on both left and right sides of an image.

[0079] Figure 9 shows an exemplary illustration 900 of yet another implementation of the present disclosure. A plan-view image generation system according to an embodiment of the present disclosure may comprise of sufficient labelled data to custom-trained machine-learning model, such as YOLO-Seg, Segment Anything, or other similar model that is capable of detecting an object's (e.g., vehicle) components from various angle and produce an output image segmentation without original image background.

[0080] Figure 10 shows an exemplary illustration 1000 of yet another implementation of the present disclosure. A plan-view image generation system according to an embodiment of the present disclosure may utilise homography matrix transformation algorithm for image perspective warping. The homography matrix transformation may

require using four coordinate points from a source image and four corresponding points from a target image to perform translation. In an example, for a wide-angle camera view, Direct Linear Transformation (DLT) implementation in OpenCV 4.x may be used as transformation algorithm for perspective correction.

[0081] Figure 11 shows an exemplary illustration 1100 of yet another implementation of the present disclosure. A plan-view image generation system according to an embodiment of the present disclosure may be configured to combine overlapping images into a seamless panorama using object key-points such as landmarks. The process may involve, identifying key features using algorithms like ORB(Oriented FAST and Rotated BRIEF) and match corresponding features in the images (Feature Detection and Matching), calculating a transformation matrix to align the images, warp one image to align with the other based on the homography (Homography Estimation & Image Warping), smoothening transitions and removing seams, performing final adjustments and cropping for a seamless result (Blending & Cropping). In an example, stitching images from multiple cameras may require the use of ORB (Oriented FAST and Rotated BRIEF) available in OpenCV 4.x as image keypoint extraction algorithm. The locations of matching keypoints may be extracted using OpenCV's 'findHomography()', and the two images may be stitched together using 'createStitcher()'.

[0082] Figure 12 shows an exemplary illustration 1200 of yet another implementation of the present disclosure. A plan-view image generation system according to an embodiment of the present disclosure may be configured to calculate a Y-coordinate relative to an Y axis of an image, wherein the Y-coordinate may be a most bottom Y-Axis value of a detected object (e.g., vehicle) in an image.

[0083] Figure 13A shows an exemplary illustration 1300 of a vehicle-end detection zone 1302 according to an embodiment of the present disclosure. A vehicle-end-detection zone 1302 in an image may be a region in the image below a vertical axis with a predefined threshold value. Any coordinate in the image that is below the vertical axis may be determined to be within the vehicle-end-detection zone 1302. In an embodiment, a method of generating a plan-view image of a location may comprise determining whether or not a position of an object is within a predefined region (e.g., 1302) of the image. If it is determined, for example, that the position of the object is within the predefined region, another image capturing the object at a different position may be used in the method for generating the plan-view image of the location.

[0084] Figure 13B show an exemplary illustration 1350 of multi-transformation-regions 1352 and 1354 according to an embodiment of the present disclosure. A multi-transformation-region is a pre-defined region that may be defined based on a predefined value of X-axis. For example, if the value of X-axis is 500, the region comprising the coordinates where the X values are less than 500 may be considered to be a multi-transformation region 1352. The multi-transformation region will be further explained in the descriptions accompanying Figure 24.

[0085] Figure 14 shows an exemplary illustration 1400 of a vehicle captured at a location according to an embodiment of the present disclosure. Images 1402, 1404, and 1406 show images of a vehicle 1408 captured at different positions and time instances T1, T5 and T9. Each position at a time instance may be determined to be a coordinate associated with the position of the vehicle in the image. In an embodiment, as the position of the vehicle 1408 falls within the predefined region 1302 of the image, the image 1406 may not be utilised in the method for generating a plan-view image of a location, as further explained in Figure 13A.

[0086] Figure 15 shows an exemplary illustration 1500 of detected components according to an embodiment of the present disclosure. Referring to images 1402 and 1406 of Figure 15, only some components of the vehicle 1408 may be detected by an image detection system according to an embodiment of the present disclosure. In the image 1402, a component 1502 may not be detected by the image detection system. It should be obvious to a skilled person in the art that not all components in the image may be detected. In an embodiment, when only one component belonging to a pair of components of an object (e.g., vehicle 1408) is detected, the further component may be estimated based on the position of the component in the image. In another embodiment, a further image capturing the object (e.g., vehicle 1408) at another position and time instance may be used to detect the pair of components.

[0087] Figure 16 shows an exemplary illustration 1600 of detected vehicle components according to an embodiment of the present disclosure. Within the detected vehicle components, a method according to an embodiment of the present disclosure may involve matching detected vehicle components in pairs according to the similarity in the shapes of the components. A component that does not have a matching pair component will not be matched to another pair. In an embodiment, positions of the matching pairs may be determined, as shown in the below table.

Image No.	Part No.	Exterior Parts (pair)	L (x, y, width, height), R (x, y, width, height)
T1 1402	1	Side-Mirror Pair 1602	L {10, 70, 10,10}, R {140, 69, 10, 11}
T1 1402	2	Fog-Light Pair 1604	L {15, 110, 30, 30}, R {135, 110, 30, 30}
T9 1404	1	Side-Mirror Pair 1602	L {225, 700, 80, 80}, R {650, 700, 80, 80}
T9 1404	2	Fog-Light Pair 1604	L {300, 930, 80, 80}, R {595, 930, 80, 80}
T9 1404	3	Head-Light Pair 1606	L {280, 820, 100, 100}, R {575, 820, 100, 100}

Table 1: A table showing coordinates associated with detected components

[0088] It will be appreciated that L and R may refer to coordinates associated with a component and a further component making up the pair of components in an image, respectively. With reference to Figure 16, the pairs of components detected in images 1402 and image 1406 are a side-mirror pair 1602 and a fog-light pair 1604. In an embodiment, the pair of components that are closer to the bottom of the images will be used in the method for generating a plan-view of a location. In this example, the fog-light pair 1406 may be utilised in the method.

[0089] Figure 17 shows an exemplary illustration 1700 of a method for determining coordinates associated with pairs of components according to an embodiment of the present disclosure. Image 1702 shows coordinates 1704, 1706, 1708 and 1710 representing the positions of the fog-light pair 1604 in images 1402 and 1406. The coordinates may be connected in lines to form a source matrix. The four coordinates in the source matrix may be used to form a target matrix with four different coordinates that may be obtained based on calculations involving the coordinates 1704, 1706, 1708 and 1710. In an embodiment, the method of forming a target matrix may start by extracting the coordinates of these components from each image to form a source matrix. In Image T1 1402, the fog-light pair is represented by coordinates that denote the positions of the left and right components. A first source coordinate 1704, (srcX1, srcY1), is determined to be {15, 110}. A second source coordinate, 1706 (srcX2, srcY2), is calculated as {165, 110}, based on the x-value of the first source coordinate plus a horizontal distance between the first and the second coordinate. In a similar manner, for Image T9 1406,

which shows the fog-light pair at a different position, a third source coordinate 1708 (srcX3, srcY3) may be determined to be {300, 1010}, and a fourth source coordinate 1710 (srcX4, srcY4) may be determined to be {675, 1010}. Together, the four source coordinates from T1 and T9 form a quadrilateral, representing the source matrix that captures the spatial relationship of the fog-light pair as seen in images 1402 and 1406.

[0090] Additionally, the source matrix may be transformed into a target matrix through a series of calculations:

tarX1 = (scrX1+scrX2) / 2 = (15+165) / 2 = 90

tarY1 = (scrY1+scrY2) / 2 = (110+110) / 2 = 110

tarX2 = (scrX3+scrX4) / 2 = (300+675) / 2 = 638

tarY2 = {scrY3+scrY4} / 2 = (1010+1010) / 2 = 1010

tarW = tarX2 – tarX = 638 – 90 = 548

tarH = tarY2 – tarY = 1010 – 110 = 900

[0091] The coordinates of the target matrix may then be calculated to be:

(tarX1, tarY1) = (90, 110)

(tarX2, tarY2) = (tarX1 + tarW, tarY1) = (90+548, 110) = (638, 110)

(tarX3, tarY3) = (tarX1, tarY1 + tarH) = (90, 110+900) = (90, 1010)

(tarX4, tarY4) = (tarX1 + tarW, tarY1 + tarH) = (90+548, 110+900) = (638, 1010)

[0092] In various embodiments to be described below, a first target coordinate 1712 (tarX1, tarY1) and a second target coordinate 1714 (tarX2, tarY2) may be referred to as a first coordinate in a first image, wherein the first coordinate is associated with a first pair of components detected in the first image 1402 capturing an object at a first position at the location. Similarly, a third target coordinate 1716 (tarX3, tarY3) and a fourth target coordinate 1718 (tarX4, tarY4) may be referred to as a second coordinate in a second image, wherein the second coordinate is associated with the first pair of components detected in the second image 1406 capturing the object at a second position at a location.

[0093] In an embodiment, a method for generating a plan-view image of a location based on an image of an object at the location may comprise determining a first coordinate (e.g., (tarX1, tarY1) 1712 or (tarX2, tarY2) 1714) in a first image, the first coordinate associated with a first pair of components detected in the first image capturing the object at a first position at the location, wherein a component of the first pair of components is positioned at a first side of the object and a further component of the first pair of components is positioned at a second side of the object that is opposite the first side.

Additionally, the method may further comprise determining a second coordinate (e.g., (tarX3, tarY3) 1716 or (tarX4, tarY4) 1718) in a second image, the second coordinate associated with the first pair of components detected in the second image capturing the object at a second position at the location, the first image and the second image being captured via a sensor device that is disposed to capture a non-plan view image of the location, and generating the plan-view image of the location based on a comparison between the first coordinate and the second coordinate.

[0094] In another embodiment, determining the first coordinate (e.g., (tarX1, tarY1) 1712 or (tarX2, tarY2) 1714) may comprise determining the first coordinate to be a mid-point between the component (represented by (scrX1,scrY1) 1704) of the first pair of components and the further component (represented by (scrX2, scrY2) 1706) of the first pair of components in the first image capturing the object at the first position of the location.

[0095] Figure 18 shows a flow chart 1800 of a process for generating a plan-view image of a location based on an image of an object at the location according to an embodiment of the present disclosure. The process depicted in the flowchart begins with acquiring a video stream from a camera. The system first evaluates whether to start detection based on predefined conditions. Once conditions are met, the video stream is decoded into multiple video frames and the video frames are processed for vehicle detection, where each frame is analysed to determine the presence of a vehicle. If a vehicle is detected, the frame is stored in a cache for further analysis; otherwise, the system evaluates whether to restart the process by decoding the video steam into multiple video streams and performing vehicle detection or end the vehicle detection.

[0096] When the vehicle is detected, the process moves to the detection 1802 and identification of mirrored pairs of vehicle components, such as fog lights 1604 or side mirrors 1602. A selection process is then performed based on specific criteria to find the mirrored pairs in the frame. These criteria may include determining the lowest pair in the frame or other predefined conditions to determine the most appropriate pair for analysis. If these selection criteria are met, the process progresses to perform dynamic perspective transformation 1806. The process concludes when this transformation has been performed. Otherwise, the system works to estimate 1804 the position of any missing components of the vehicle's mirrored pairs. The steps relating to mirror pair detection 1802, estimation of missing vehicle exterior pain component 1804 and dynamic

perspective transformation 1806 will be further described in descriptions accompanying Figures 19, 21 and 24.

[0097] Figure 19 shows an exemplary illustration 1900 of images of a vehicle taken at different time instances. Each image, taken at time instances T1 – T7, comprises of a vehicle at a different position at the location in the image. For each image, an image detection system according to an embodiment of the present disclosure may detect different pairs of components for each image. For example, the system may only detect a left fog-light and a right fog-light in the image 1902 taken at a time instance T1, and fail to detect a left side mirror and a right side mirror in the image. Additionally, the same pair of left fog-light and right fog-light detected in the image 1902 may be detect at image 1904 taken at time instance T6. The positions of the fog-light pair detected in image 1902 and image 1904 may be utilised in a method for generating a plan-view image of a location according to an embodiment of the present disclosure.

[0098] In an embodiment, a method for generating the plan-view image of the location may further comprise determining whether or not a pair of components (e.g., a pair of fog lights 1604 or a pair of side mirrors 1602) may be detected in an image capturing the object at a position at the location. If it is determined that a pair of components is not detected in the image, another image wherein the pair of components (e.g., a pair of fog lights 1604 or a pair of side mirror 1602) can be detected may be used in the method for generating the plan-view image. An advantageous effect of this may be that multiple images may be analysed to determine a suitable image to be used in the method for generating a plan-view of a location.

[0099] Figure 20 shows an exemplary embodiment 2000 of a vehicle taken at different positions according to an embodiment of the present disclosure. In an embodiment, a selection criteria as mentioned in Figure 18 of the present disclosure may be that a minimum number of pixels must be between a centre point in the first image 1902 and the centre point of the object in the second image 1904. In another embodiment, the image 1902 and 1904 must be two images taken with a largest position gap. Additionally, a pair of the component that is detected in images 1902 and 1904 must be the closest pair of components to the ground. An advantageous effect of this may be that images wherein the positions of the object that are too close to each other may not be used to generate the plan-view image. This ensures that spatial distribution in the generated plan-view image can be observed,

[0100] In an embodiment, a method for generating a plan-view image of a location may comprise, determining whether or not a first pair of components of an object is detected in a first image capturing the object at a first position at the location, and determining whether or not the first pair of components is positioned lower than a second pair of components in the first image. An advantageous effect of this may be that a plan-view image generated with images of components that are closest to the ground will show the spatial distribution of a location more accurately.

[0101] In another embodiment, a method for generating a plan-view image of a location may further comprise calculating a number of pixels between a first centre point of an object at a first position and a second centre point of the object at a second position, and determining whether or not the number of pixels is lower than a threshold value.

[0102] Figure 21 shows a flowchart 2100 illustrating a method for detecting unevenness at a location according to an embodiment of the present disclosure.

[0103] The method may begin with step 2102, wherein centre points of detected pair of components in an image may be calculated. In step 2104, the difference in y-coordinate values of the centre points may be calculated. Subsequently, in step 2106, the difference in y-coordinate values of the centre points may be compared with a pre-defined configuration value, “horizontal-range-pixels”. If the difference in y-coordinate values of the centre points are lower than the pre-defined configuration value, an object in the image with the detected pair of components may be determined to be on a levelled ground in step 2108. Conversely, if the difference in y-coordinate values of the centre points are greater than the pre-defined configuration value, an object in an image may be determined to be on an uneven ground in step 2110.

[0104] Figure 22 shows an exemplary illustration 2200 of a method for calculating the centre points of detected pair of components in an image according to an embodiment of the present disclosure. In an example, a pair of components may be detected in an image 2202. A first component 2204 may be associated with coordinates having x and y values of (20,192), while a second component 2206 may be associated with coordinates having a x and y value of (490,172). An image detection system according to an embodiment of the present disclosure may be detect the number of pixels representing a width 2208 and height 2210 of the detected components. In an example, a coordinate representing the centre point of the first component 2204 may be determined. With reference to the first component 2204, an x-value of the coordinate of the centre point may be derived by dividing the width by 2 and adding the x-value of 20, resulting in 65.

Y-value of the coordinate of the centre point may be determined by dividing the height by 2 and adding a y-value of 220. The coordinate of the centre point may then be determined to be (65, 220). Using the same method, a coordinate of a centre point of the second component 2206 may be determined to be (535, 200).

[0105] Figure 23 shows an exemplary illustration 2300 of vehicles on levelled and uneven grounds according to an embodiment of the present disclosure. Image 2302 shows an image of a vehicle at a levelled-ground, while image 2304 shows an image of a vehicle at an uneven-ground. In an example, a pre-defined configuration threshold value may be used to determine if an object is on a levelled ground or an uneven ground. Referring to image 2302, a vehicle may comprise of a pair of components 2306 and 2308. Each component may have a y-coordinate value associated with a position of the component within the image, and the y-coordinate of the first component 2306 may be 220 while the y-coordinate of the second component 2308 may be 221. The difference in the values of the y – coordinates of the first component 2306 and the second component 2308 will then be equal to 1. If the configuration threshold value is pre-defined to be a value equal to 5, the difference between the values of the y- coordinates, 1, will be lower than the pre-defined configuration value. In this case, the vehicle may be on a levelled ground. In another example, y -coordinate of a third component 2310 may be 220 while a y-coordinate of a fourth component 2312 may be 200. As the difference between the values of the y-coordinates, 20, is greater than the pre-defined configuration value of 5, a vehicle in the image 2304 may be on an uneven ground.

[0106] Figure 24 shows an exemplary illustration 2400 of a method for estimating a position of a missing component of an object according to an embodiment of the present disclosure. Figure 24 comprises of a detected fog-light component 2402 and a detected headlight component 2404. Once a component (e.g., 2402) is detected, the coordinate associated with the component and the length and width of the component may be automatically detected by the image-detection system according to an embodiment of the present disclosure. Further, whether the detected component is at a first side of the vehicle may be determined based on the width of an object detected (e.g., vehicle 2406). In an embodiment, a mid-point of the width of the vehicle may be calculated, for example, to give a value of 300. If a coordinate associated with the detected component 2402 has a x-value that is less than a value of 300, the detected component 2402 may be considered to be a “left” component of the pair of components. Similarly, if a coordinate associated with the detected component 2406 has an x-value that is greater than a value

of 300, the detected component 2406 may be considered to be a “right” component of the pair of components. By subtracting the x-value of the coordinate associated with the left component 2402 and the width of the detected left component 2402 from the width of the vehicle, a x-value of the coordinate associated with the right component 2406 at the opposite side of the left component 2402 may be estimated. In another embodiment, the y- value of the coordinate associated with the left component 2402 may be identical to a y-value of a coordinate associated with the right component 2406 at the opposite side of the left component 2402. An advantageous effect of this may be that a non-plan view image wherein a pair of components is not detected may also be used to generate a plan-view image of a location.

[0107] In an embodiment, a method for generating a plan-view image of a location may comprise, determining a position of a component of a pair of components in a first image capturing an object at a first position at the location, determining a length of the object in the first image, and estimating a position of a further component of the pair of components based on the position of the component of the pair of components and the length of the object.

[0108] Figure 25 shows an exemplary illustration 2500 of another method for estimating a position of a missing component of an object according to an embodiment of the present disclosure. In real life examples, an object such as a vehicle, may not always be in an upright position due to unevenness (e.g., 2502 or 2504) on the ground. Utilising lengths and angles that may be in a triangular shape 2214 formed by detected components (e.g., 2506, 2508 or 2510) of the object, a position of an undetected component 2512 may be estimated by generating a triangular shape 2516 that is a mirrored counterpart of the triangular shape 2514. An advantageous effect of this may be that a component that is not detected in an image may be estimated even if there may be unevenness on the road such that the object comprising the component is slanted at an angle to the ground.

[0109] Figure 26 shows an exemplary illustration 2600 of a method for calculating a coordinate associated with a missing component according to an embodiment of the present disclosure. The components 2506, 2508 and 2510 as described in Figure 24 may be used to calculate a vertical line of reflection 2602. For example, the x-coordinate of the vertical line of reflection 2602 may be calculated by dividing a value of an x–coordinate representing the left-most component in the image (e.g., 2506) with a value

of an x – value associated with a coordinate representing the right- most component in the image (e.g. 2510). In an example, if the x - coordinate of a centre point of the component 2506 has a value of 200 and the x-coordinate of a centre point of the component 2510 has a value of 700, the x coordinate of the vertical line of reflection 2602 may be calculated to be 450. A triangular shape 2604 formed by the components may be reflected about the vertical line of reflection 2602 to form a mirrored triangular shape 2606. A mirrored triangular shape 2606 may comprise of three mirrored coordinates 2608, 2610 and 2612 which may each represent a mirrored position of the three components 2506, 2508 and 2510. In an example, an x-coordinate associated with a mirrored coordinate 2608 may be calculated by subtracting the x-coordinate of the first component 2506, 200, from a product of the x-coordinate of the vertical line of reflection 2602, 450, with a value of 2. In another example, a y-coordinate associated with the mirrored coordinate 2608 may be identical to the y-coordinate associated with the first component 2506. This may result in the mirrored coordinate 2608 being (700,200). Similarly, the mirrored coordinates 2610 and 2612 may be calculated to be (500, 500) and (200, 400), respectively.

[0110] Figure 27 shows an exemplary illustration 2700 of another method for calculating a coordinate associated with a missing component according to an embodiment of the present disclosure. It will be appreciated that coordinates representing the centre points of the components 2506, 2508 and 2510 may be referred to as P1, P2 and P3, respectively. Similarly, the mirrored coordinates 2608, 2610 and 2612 may be referred to as M1, M2, and M3 respectively. In an example, the following calculations involving dot product and cosine rule may be performed to find an angle 2702 formed between a line 2704 connecting P2 and P3 and a line 2706 connecting M3 and M2:

$$\overrightarrow{M3M2} = (M2.x - M3.x, M2.y - M3.y) = (500 - 200, 500 - 400) = (300, 100)$$

$$\overrightarrow{P2P3} = (P3.x - P2.x, P3.y - P2.y) = (700 - 400, 400 - 500) = (300, -100)$$

$$\overrightarrow{M3M2} \cdot \overrightarrow{P2P3} = (300 \times 300) + (100 \times -100) = 80{,}000$$

$$|\overrightarrow{M3M2}| = \sqrt{200^2 + 100^2} = 316.228\ pixels$$

$$|\overrightarrow{P2P3}| = \sqrt{200^2 + (-100)^2} = 316.228\ pixels$$

$$r = \cos^{-1}\left(\frac{80.000}{316.228 * 316.228}\right) = \cos^{-1}\left(\frac{80.000}{100{,}000}\right) = 0.6435\ radians = 36.81°$$

After the angle, r, is calculated, a rotation direction may be determined based on a cross product:

$$\overrightarrow{M3M2} \times \overrightarrow{P2P3} = (300 \times 100) - (-100 \times 300) = 60{,}000$$

If the cross product is positive, the mirrored triangle 2606 may be rotated anti-clockwise by 36.81 degrees (r; 2702) to form a rotated triangle.

[0111] Figure 28 shows an exemplary illustration 2800 of yet another method for calculating a coordinate associated with a missing component according to an embodiment of the present disclosure. In an example, the triangle formed by the mirrored coordinates M1, M2 and M3 may be rotated to form a rotated triangle 2802 with coordinates C1 2804, C2 2806 and C3 2808. Referring to the examples as described in figures 26 and 27, the coordinates C1, C2 and C3 may be calculated via the following calculations:

$$C1.x = 200 + (700 - 200)cos(36.81°) - (200 - 400)\sin(36.81°) = 720$$

$$C1.y = 400 + (700 - 200)sin(36.81°) + (200 - 400)\cos(36.81°) = 650$$

$$C1 = (720{,}540)$$

$$C2 = P3 = (700{,}400)$$

$$C3 = P2 = (400{,}5000)$$

Based on the above calculation, the position of the missing component may be estimated to be at the coordinate of C1 2804.

[0112] In an example, a method for estimating a position of the missing component, C1, may comprise determining a position (e.g., P1) of a component of a second pair of components in an image, estimating a position (e.g., C1) of a further component in the image based on the positions of three other components (e.g., P1, P2 and P3).

[0113] In another example, a method for estimating the position, C1, of the missing component, C1, may further comprise determining the position of the missing component based on an angle (e.g., 2702) that is calculated based on the positions of three other components (e.g., P1, P2, P3). An advantage of this method may be that the position of the missing component may be determined even when an object is on an uneven ground by calculating the angle related to the unevenness.

[0114] Figure 29 shows an exemplary illustration 2900 of a method for generating a plan-view image according to an embodiment of the present disclosure. As described in embodiments of the present disclosure, two images 2902 and 2904 may be used to generate a plan-view image of a location. In an embodiment, the location may be a single lane in a toll gate. The images 2902 and 2904 may have predefined multi-transformation regions 2906 at two ends of the images. In an embodiment, if a source matrix generated

based on the two images 2902 and 2904 according to a method as described in Figure 17 falls within the multi-transformation region, an image detection system according to an embodiment of the present disclosure may be alerted that there may be another object at different position from an object detected at an original position. This is further described in Figure 30.

[0115] Figure 30 shows another exemplary illustration 3000 of a method for generating a plan-view image according to an embodiment of the present disclosure. Two images 3002 and 3004 may be used to generate a plan-view image of a location. An area occupied by a source matrix 3006 in the images may fall within a predefined multi-transformation region 3008 in the images. If a percentage of a region covered by the source matrix 3008 falls within the multi-transformation region by more than a predefined threshold percentage, the image detection system may determine that there may be a second object at a different position from a first object at the location. Based on a source matrix 3006 of the first object, an estimation of a further source matrix 3010 of the second object may be generated. In an example, the further source matrix 3010 may be calculated by $B\{x,y\} = \{Frame.width - A.x, A.y\}$, wherein A and B refer to the coordinates of the source matrix 3006 and the coordinates of the further source matrix 3010, respectively. The further source matrix may be used to generate the plan-view image of the location based on the methods as disclosed in the embodiments of the present disclosure. An advantageous effect of this may be that a plan-view image generated based on this embodiment will show a spatial distribution of a plurality of objects at the location.

[0116] In an embodiment, a method for generating a plan-view image of a location may comprise determining a percentage of an area occupied by an object in a first image capturing the object at a first position at the location that is within a predefined region in the first image, determining if the percentage of the area occupied by the object in the first image that is within the predefined region in the first image is less than a predefined threshold percentage. Based on a determination that the percentage of the area occupied by the object in the first image is less than the predefined threshold percentage, a first coordinate in the first image associated with a pair of components detected in the first image capturing a further object at another position at the location, wherein a component of the pair of components is positioned at a first side of the further object and a further component of the pair of components is positioned at a second side of the second object that is opposite the first side of the further object, may be determined. This may be followed by determining a second coordinate in a second image associated with

the pair of components detected in the second image capturing the further object at a further position at the location, and generating a part of the plan-view image of the location based on a comparison of the first coordinate and the second coordinate. In a further example, a third coordinate in the first image and a fourth coordinate in the second image may be calculated based on the equation $B\{x, y\} = \{Frame.width - A.x, A.y\}$. A remaining part of the plan-view image may be generated based on a comparison between the third coordinate and the fourth coordinate.

[0117] Figure 31 depicts an exemplary computing device 3100, hereinafter interchangeably referred to as a computer system 3100, where one or more such computing devices 3100 may be used to execute the method of Figure 3. The exemplary computing device 3100 can be used to implement an apparatus for determining an optimal position of a vehicle. In an implementation, a system for determining an optimal position of a vehicle may comprise the apparatus and one or more image and video capturing apparatuses configured to capture one or more images or video frames, wherein the one or more images or video frames comprises an image of a vehicle. The following description of the computing device 3100 is provided by way of example only and is not intended to be limiting.

[0118] As shown in Figure 31, the example computing device 3100 includes a processor 3104 for executing software routines. Although a single processor is shown for the sake of clarity, the computing device 3100 may also include a multi-processor system. The processor 3104 is connected to a communication infrastructure 3106 for communication with other components of the computing device 3100. The communication infrastructure 3106 may include, for example, a communications bus, cross-bar, or network.

[0119] The computing device 3100 further includes a main memory 3108, such as a random access memory (RAM), and a secondary memory 3110. The secondary memory 3110 may include, for example, a storage drive 3112, which may be a hard disk drive, a solid state drive or a hybrid drive and/or a removable storage drive 3114, which may include a magnetic tape drive, an optical disk drive, a solid state storage drive (such as a USB flash drive, a flash memory device, a solid state drive or a memory card), or the like. The removable storage drive 3114 reads from and/or writes to a removable storage medium 3118 in a well-known manner. The removable storage medium 3118 may include magnetic tape, optical disk, non-volatile memory storage medium, or the like, which is read by and written to by removable storage drive 3114. As will be appreciated by persons skilled in the relevant art(s), the removable storage medium 3118 includes a

computer readable storage medium having stored therein computer executable program code instructions and/or data.

[0120] In an alternative implementation, the secondary memory 3110 may additionally or alternatively include other similar means for allowing computer programs or other instructions to be loaded into the computing device 3100. Such means can include, for example, a removable storage unit 3122 and an interface 3120. Examples of a removable storage unit 3122 and interface 3120 include a program cartridge and cartridge interface (such as that found in video game console devices), a removable memory chip (such as an EPROM or PROM) and associated socket, a removable solid state storage drive (such as a USB flash drive, a flash memory device, a solid state drive or a memory card), and other removable storage units 3122 and interfaces 3120 which allow software and data to be transferred from the removable storage unit 3122 to the computer system 3100.

[0121] The computing device 3100 also includes at least one communication interface 3124. The communication interface 3124 allows software and data to be transferred between computing device 3100 and external devices via a communication path 3126. In various embodiments of the inventions, the communication interface 3124 permits data to be transferred between the computing device 3100 and a data communication network, such as a public data or private data communication network. The communication interface 3124 may be used to exchange data between different computing devices 2500 which such computing devices 3100 form part an interconnected computer network. Examples of a communication interface 3124 can include a modem, a network interface (such as an Ethernet card), a communication port (such as a serial, parallel, printer, GPIB, IEEE 1394, RJ45, USB), an antenna with associated circuitry and the like. The communication interface 3124 may be wired or may be wireless. Software and data transferred via the communication interface 3124 are in the form of signals which can be electronic, electromagnetic, optical or other signals capable of being received by communication interface 3124. These signals are provided to the communication interface via the communication path 3126.

[0122] As shown in Figure 31, the computing device 3100 further includes a display interface 3102 which performs operations for rendering images or videos to an associated display 3130 and an audio interface 3132 for performing operations for playing audio content via associated speaker(s) 3134.

[0123] As used herein, the term "computer program product" may refer, in part, to removable storage medium 3118, removable storage unit 3122, a hard disk installed in storage drive 3112, or a carrier wave carrying software over communication path 3126 (wireless link or cable) to communication interface 3124. Computer readable storage media refers to any non-transitory, non-volatile tangible storage medium that provides recorded instructions and/or data to the computing device 3100 for execution and/or processing. Examples of such storage media include magnetic tape, CD-ROM, DVD, Blu-ray Disc, a hard disk drive, a ROM or integrated circuit, a solid state storage drive (such as a USB flash drive, a flash memory device, a solid state drive or a memory card), a hybrid drive, a magneto-optical disk, or a computer readable card such as a PCMCIA card and the like, whether or not such devices are internal or external of the computing device 3100. Examples of transitory or non-tangible computer readable transmission media that may also participate in the provision of software, application programs, instructions and/or data to the computing device 3100 include radio or infra-red transmission channels as well as a network connection to another computer or networked device, and the Internet or Intranets including e-mail transmissions and information recorded on Websites and the like.

[0124] The computer programs (also called computer program code) are stored in main memory 3108 and/or secondary memory 3110. Computer programs can also be received via the communication interface 3124. Such computer programs, when executed, enable the computing device 3100 to perform one or more features of embodiments discussed herein. In various embodiments, the computer programs, when executed, enable the processor 3104 to perform features of the above-described embodiments. Accordingly, such computer programs represent controllers of the computer system 3100.

[0125] Software may be stored in a computer program product and loaded into the computing device 3100 using the removable storage drive 3114, the storage drive 3112, or the interface 3120. The computer program product may be a non-transitory computer readable medium. Alternatively, the computer program product may be downloaded to the computer system 3100 over the communications path 3126. The software, when executed by the processor 3104, causes the computing device 3100 to perform the necessary operations to execute the method as shown in Figure 3.

[0126] It is to be understood that the embodiment of Figure 31 is presented merely by way of example to explain the operation and structure of an apparatus for tracking a movement of an object. Therefore, in some embodiments one or more features of the

computing device 3100 may be omitted. Also, in some embodiments, one or more features of the computing device 3100 may be combined together. Additionally, in some embodiments, one or more features of the computing device 3100 may be split into one or more component parts.

[0127] It will be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

CLAIMS

1. A method for generating a plan-view image of a location based on an image of an object at the location, comprising:

determining, by a processor, a first coordinate in a first image, the first coordinate associated with a first pair of components detected in the first image capturing the object at a first position at the location, wherein a component of the first pair of components is positioned at a first side of the object and a further component of the first pair of components is positioned at a second side of the object that is opposite the first side;

determining, by the processor, a second coordinate in a second image, the second coordinate associated with the first pair of components detected in the second image capturing the object at a second position at the location, the first image and the second image being captured via a sensor device that is disposed to capture a non-plan view image of the location; and

generating, by the processor, the plan-view image of the location based on a comparison between the first coordinate and the second coordinate.

2. The method of claim 1, wherein determining the first coordinate in the first image further comprises:

determining the first coordinate to be a mid-point between the component of the first pair of components and the further component of the first pair of components in the first image capturing the object at the first position at the location.

3. The method according to any one of claims 1 or 2, wherein generating the plan-view image of the location further comprises:

determining whether or not a second pair of components of the object is detected in the first image capturing the object at the first position at the location;

determining whether or not the first pair of components is positioned lower than the second pair of components in the first image; and

generating the plan-view image of the location based on a comparison of the first coordinate in the first image and the second coordinate in the second image, based on a result of the determination of whether or not the first pair of

components is positioned lower than the second pair of components in the first image.

4. The method according to any one of claims 1 - 3, wherein generating the plan-view image of the location further comprises:

determining whether or not the first pair of components can be detected in the second image capturing the object at the second position at the location;

determining a third coordinate associated with the first pair of components detected in a third image capturing the object at a third position at the location based on a result of the determination of whether or not the first pair of components can be detected in the second image, the third image being captured via the sensor device; and

generating the plan view image of the location based on a comparison of the first coordinate in the first image and the third coordinate in the third image.

5. The method according to any one of claims 1 – 3, wherein determining the first coordinate in the first image further comprises:

determining a position of the component of the first pair of components in the first image capturing the object at the first position at the location;

determining a length of the object in the first image; and

estimating a position of the further component of the first pair of components based on the position of the component of the first pair of components and the length of the object.

6. The method according to claims 3, wherein determining the first coordinate in the first image further comprises:

determining a position of a component of the second pair of components in the first image, the position being represented by one or more coordinates that are associated with one or more pixels representing the component in the first image; and

estimating a position of a further component of the second pair of components based on:

the position of the component of the second pair of components in the first image;

a position associated with a component of the first pair of components in the first image; and

a further position associated with a further component of the first pair of components in the first image.

7. The method of claim 6, wherein estimating the position of the further component of the second pair of components further comprises:

determining the position of the further component of the second pair of components based on an angle that is calculated based on:

the position of the component of the second pair of components in the first image;

the position associated with the component of the first pair of components in the first image; and

the further position associated with the further component of the first pair of components in the first image.

8. The method according to any one of claims 1 - 3, wherein generating the plan-view image of the location further comprises:

determining whether or not the second position of the object in the second image capturing the object at a second position at the location is within a predefined region of the second image;

determining a third coordinate associated with the first pair of components detected in a third image capturing the object at a third position at the location based on a result of the determination of whether or not the second position of the object in the second image is within the predefined region of the second image, the third image being captured via the sensor device; and

generating the plan-view image of the location based on a comparison of the first coordinate in the first image and the third coordinate in the third image.

9. The method according to any one of claims 1 - 3, wherein generating the plan-view image of the location further comprises:

calculating a number of pixels between a first centre point of the object at the first position and a second centre point of the object at the second position;

determining whether or not the number of pixels is lower than a threshold value;

determining a third coordinate associated with the first pair of components detected in a third image capturing the object at a third position at the location based on a result of the determination of whether or not the number of pixels is lower than the threshold value, the third image being captured via the sensor device; and

generating the plan view image of the location based on a comparison of the first coordinate in the first image and the third coordinate in the third image based on a result of the determination of whether or not the number of pixels is lower than the threshold value.

10. The method according to any one of claims 1 – 3, wherein generating the plan-view image of the location further comprises:

determining a percentage of an area occupied by the object in the first image capturing the object at the first position at the location that is within a predefined region in the first image;

determining if the percentage of the area occupied by the object in the first image that is within the predefined region in the first image is less than a predefined threshold percentage;

generating, based on a result of the determination on whether the percentage of the area occupied by the object in the first image that is within the predefined region in the first image is less than the predefined threshold percentage, a part of the plan-view image of the location based on a comparison between the first coordinate and the second coordinate;

calculating a third coordinate in the first image and a fourth coordinate in the second image based on the first coordinate, the second coordinate and a width of the first image, wherein the width of the first image is a number of pixels from one side of the first image to an opposite side of the first image; and

generating a remaining part of the plan-view image of the location based on a comparison between the third coordinate and the fourth coordinate.

11. An apparatus for generating a plan-view image of a location based on an image of an object at the location, comprising:

at least one processor; and

at least one memory including computer program code; the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to:

determine a first coordinate in a first image, the first coordinate associated with a first pair of components detected in the first image capturing the object at a first position at the location, wherein a component of the first pair of components is positioned at a first side of the object and a further component of the first pair of components is positioned at a second side of the object that is opposite the first side;

determine a second coordinate in a second image, the second coordinate associated with the first pair of components detected in the second image capturing the object at a second position at the location, the first image and the second image being captured via a sensor device that is disposed to capture a non-plan view image of the location; and

generate the plan-view image of the location based on a comparison between the first coordinate and the second coordinate.

12. The apparatus of claim 11, wherein determining the first coordinate in the first image further comprises:

determining the first coordinate to be a mid-point between the component of the first pair of components and the further component of the first pair of components in the first image capturing the object at the first position at the location.

13. The apparatus according to any one of claims 11 or 12, wherein generating the plan-view image of the location further comprises:

determining whether or not a second pair of components of the object is detected in the first image capturing the object at the first position at the location;

determining whether or not the first pair of components is positioned lower than the second pair of components in the first image; and

generating the plan-view image of the location based on a comparison of the first coordinate in the first image and the second coordinate in the second image, based on a result of the determination of whether or not the first pair of components is positioned lower than the second pair of components in the first image.

14. The apparatus according to any one of claims 11 – 13, wherein generating the plan-view image of the location further comprises:

determining whether or not the first pair of components can be detected in the second image capturing the object at the second position at the location;

determining a third coordinate associated with the first pair of components detected in a third image capturing the object at a third position at the location based on a result of the determination of whether or not the first pair of components can be detected in the second image, the third image being captured via the sensor device; and

generating the plan view image of the location based on a comparison of the first coordinate in the first image and the third coordinate in the third image.

15. The apparatus according to any one of claims 11 - 13, wherein determining the first coordinate in the first image further comprises:

determining a position of the component of the first pair of components in the first image capturing the object at the first position at the location;

determining a length of the object in the first image; and

estimating a position of the further component of the first pair of components based on the position of the component of the first pair of components and the length of the object.

16. The apparatus according to claims 13, wherein determining the first coordinate in the first image further comprises:

determining a position of a component of the second pair of components in the first image, the position being represented by one or more coordinates that are associated with one or more pixels representing the component in the first image; and

estimating a position of a further component of the second pair of components based on:

the position of the component of the second pair of components in the first image;

a position associated with a component of the first pair of components in the first image; and

a further position associated with a further component of the first pair of components in the first image.

17. The apparatus according claim 16, wherein estimating the position of the further component of the second pair of components further comprises:

determining the position of the further component of the second pair of components based on an angle that is calculated based on:

the position of the component of the second pair of components in the first image;

the position associated with the component of the first pair of components in the first image; and

the further position associated with the further component of the first pair of components in the first image.

18. The apparatus according to any one of claims 11 - 13, wherein generating the plan-view image of the location further comprises:

determining whether or not the second position of the object in the second image capturing the object at a second position at the location is within a predefined region of the second image;

determining a third coordinate associated with the first pair of components detected in a third image capturing the object at a third position at the location based on a result of the determination of whether or not the second position of the object in the second image is within the predefined region of the second image, the third image being captured via the sensor device; and

generating the plan-view image of the location based on a comparison of the first coordinate in the first image and the third coordinate in the third image.

19. The apparatus according to any one of claims 11 – 13, wherein generating the plan-view image of the location further comprises:

calculating a number of pixels between a first centre point of the object at the first position and a second centre point of the object at the second position;

determining whether or not the number of pixels is lower than a threshold value;

determining a third coordinate associated with the first pair of components detected in a third image capturing the object at a third position at the location based on a result of the determination of whether or not the number of pixels is lower than the threshold value, the third image being captured via the sensor device; and

generating the plan view image of the location based on a comparison of the first coordinate in the first image and the third coordinate in the third image based on a result of the determination of whether or not the number of pixels is lower than the threshold value.

20. The apparatus according to any one of claims 11 – 13, wherein generating the plan-view image of the location further comprises:

determining a percentage of an area occupied by the object in the first image capturing the object at the first position at the location that is within a predefined region in the first image;

determining if the percentage of the area occupied by the object in the first image that is within the predefined region in the first image is less than a predefined threshold percentage;

generating, based on a result of the determination on whether the percentage of the area occupied by the object in the first image that is within the predefined region in the first image is lees than the predefined threshold percentage, a part of the plan-view image of the location based on a comparison between the first coordinate and the second coordinate;

calculating a third coordinate in the first image and a fourth coordinate in the second image based on the first coordinate, the second coordinate and a number of pixels representing a length of the first image; and

generating a remaining part of the plan-view image of the location based on a comparison between the third coordinate and the fourth coordinate.

21. A system for generating a plan-view image of a location based on an image of an object at the location, comprising the apparatus of any one of claims 11 – 20.