

DISPLAY IMAGE GENERATION METHOD, APPARATUS, STORAGE MEDIUM AND DEVICE

TECHNICAL FIELD

[0001] This disclosure relates to the technologies of man-machine interaction, and in particular, to a display image generation method, an apparatus, a storage medium, and a device.

BACKGROUND

[0002] With the vehicle sentry mode gradually becoming a core security configuration of mainstream vehicle models, users have increasing demands for the warning effect of suspicious objects outside the vehicle in the sentry mode. In the related art, external warnings are typically provided through audio and visual signals, which yield a suboptimal warning effect.

SUMMARY

[0003] The present disclosure provides a display image generation method, an apparatus, a storage medium and a device, for directionally warning suspicious target objects, thereby improving the warning effect.

[0004] According to a first aspect of embodiments of the present disclosure, a display image generation method is provided. The display image generation method includes: in a sentry mode, in response to determining that a candidate object to be warned is present in a vicinity of a vehicle, determining an azimuth angle of the candidate object relative to a display screen based on a first position of the candidate object in a first coordinate system and a second position of the display screen in the first coordinate system; determining a target gaze direction of a virtual interactive avatar based on the azimuth angle; and rendering the virtual interactive avatar based on the target gaze direction, to generate a display image in which the virtual interactive avatar

gazes at a target object in the target gaze direction.

[0005] According to a second aspect of embodiments of the present disclosure, a display image generation apparatus is provided. The display image generation apparatus includes: a first processing module configured to in a sentry mode, in response to determining that a candidate object to be warned is present in a vicinity of a vehicle, determine an azimuth angle of the candidate object relative to a display screen based on a first position of the candidate object in a first coordinate system and a second position of the display screen in the first coordinate system; a second processing module configured to determine a target gaze direction of a virtual interactive avatar based on the azimuth angle; and a third processing module configured to render the virtual interactive avatar based on the target gaze direction, to generate a display image in which the virtual interactive avatar gazes at a target object in the target gaze direction.

[0006] According to a third aspect of embodiments of the present disclosure, a computer-readable storage medium is provided. A computer program is stored on the computer-readable storage medium. The computer program, when executed by a processor, implements the display image generation method according to any embodiment of the present disclosure.

[0007] According to a fourth aspect of embodiments of the present disclosure, an electronic device is provided. The electronic device includes: a memory configured to store executable instructions by a processor; and the processor configured to read the executable instructions from the memory, and execute the instructions to perform the display image generation method according to any embodiment of the present disclosure.

[0008] According to a fifth aspect of the embodiments of the present disclosure, a computer program product is provided, wherein when instructions in the computer program product are executed by a processor, the display image generation method according to any embodiment of the present disclosure is performed.

[0009] According to the display image generation method, an apparatus, a storage medium and a device provided by embodiments of the present disclosure, a vehicle can in a sentry mode, in response to determining that the candidate object to be warned is present in a vicinity of the vehicle, determine an azimuth angle of the candidate object relative to the display screen based on the first position of the candidate object in the first coordinate system and the second position of the display screen in the first coordinate system; then determine the target gaze direction of the virtual interactive avatar based on the azimuth angle; and thereafter render the virtual interactive avatar based on the target gaze direction, to generate a display image in which the virtual interactive avatar gazes at the target object in the target gaze direction, so that upon observing the virtual interactive avatar gazing at the target object, the target object can perceive being actively tracked, thereby producing direct psychological deterrence on the target object, achieving a directional warning function, and effectively improving the warning effect.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is an exemplary application scenario of an embodiment of the present disclosure.

[0011] FIG. 2 is a schematic flowchart of a display image generation method according to an exemplary embodiment of the present disclosure.

[0012] FIG. 3 is a schematic flowchart of a display image generation method according to another exemplary embodiment of the present disclosure.

[0013] FIG. 4 is a schematic flowchart of a display image generation method according to yet another exemplary embodiment of the present disclosure.

[0014] FIG. 5 is a schematic diagram of a calculation principle of an azimuth angle of a candidate object according to an exemplary embodiment of the present disclosure.

[0015] FIG. 6 is a schematic flowchart of a display image generation method according to still

another exemplary embodiment of the present disclosure.

[0016] FIG. 7 is a schematic diagram of a determination of a target object from candidate objects according to an exemplary embodiment of the present disclosure.

[0017] FIG. 8 is a schematic diagram of a visualization of a virtual interactive avatar according to an exemplary embodiment of the present disclosure.

[0018] FIG. 9 is a schematic diagram of a display effect of a display image according to an exemplary embodiment of the present disclosure.

[0019] FIG. 10 is a schematic flowchart of a display image generation method according to yet another exemplary embodiment of the present disclosure.

[0020] FIG. 11 is a schematic flowchart of a display image generation method according to still another exemplary embodiment of the present disclosure.

[0021] FIG. 12 is a schematic diagram of a structure of a display image generation apparatus according to an exemplary embodiment of the present disclosure.

[0022] FIG. 13 is a schematic diagram of a structure of a display image generation apparatus according to another exemplary embodiment of the present disclosure.

[0023] FIG. 14 is a schematic diagram of a structure of a display image generation apparatus according to still another exemplary embodiment of the present disclosure.

[0024] FIG. 15 is a diagram of a structure of an electronic device according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0025] For the purpose of illustrating the present disclosure, example embodiments of the present disclosure will be described in detail below with reference to the accompanying drawings. Obviously, the described embodiments are only a part of the embodiments of the present disclosure, rather than all of the embodiments. It should be understood that the present disclosure

is not limited by the exemplary embodiments.

[0026] It should be noted that the relative arrangement of components and steps, numerical expressions, and numerical values set forth in these embodiments do not limit the scope of the present disclosure unless specifically stated otherwise.

Summary of the Application

[0027] In the process of implementing the present disclosure, the inventor found that, with the vehicle sentry mode gradually becoming a core security configuration of mainstream vehicle models, users have increasing demands for the warning effect of suspicious objects outside the vehicle in the sentry mode. In the related art, external warnings are typically provided through audio and visual signals, which yield a suboptimal warning effect.

Exemplary Summary

[0028] FIG. 1 is an exemplary application scenario of an embodiment of the present disclosure. As shown in FIG. 1, when a vehicle (or called an ego vehicle) 11 is parked in a certain area, for example, but not limited to, a parking lot 12, a sentry mode may be turned on, and a display image is generated using the display image generation method of the present disclosure, and is displayed on a display screen 13 of the ego vehicle 11 to provide an external warning.

[0029] Specifically, in the sentry mode, in response to determining that a candidate object to be warned is present in a vicinity of the vehicle 11, determining an azimuth angle of the candidate object relative to the display screen 13 based on a first position of the candidate object in a first coordinate system and a second position of the display screen 13 in the first coordinate system; then determining a target gaze direction of a virtual interactive avatar based on the azimuth angle; and thereafter rendering the virtual interactive avatar based on the target gaze direction, to generate a display image in which the virtual interactive avatar gazes at a target

object 14 in the target gaze direction, so that upon observing the virtual interactive avatar gazing at the target object, the target object 14 can perceive being actively tracked, thereby producing direct psychological deterrence on the target object 14, achieving a directional warning function, and effectively improving the warning effect.

Exemplary Methods

[0030] FIG. 2 is a schematic flowchart of a display image generation method according to an exemplary embodiment of the present disclosure. The display image generation method according to the embodiment of the present disclosure can be applied to an electronic device, an in-vehicle computing platform, or a System on Chip (SoC) and a Microprogrammed Control Unit (MCU) in the in-vehicle computing platform, or to hardware and/or software in the electronic device or the System on Chip. The electronic device includes, for example, but not limited to, a server, a terminal device (e.g., an in-vehicle terminal), an embodied agent, and the like, and the System on Chip includes, for example, but not limited to, a System on Chip on an in-vehicle terminal, a System on Chip on an embodied agent, and the like. As shown in FIG. 2, the method of the present disclosure may include steps 210-230 as follows:

[0031] At step 210, in a sentry mode, in response to determining that a candidate object to be warned is present in a vicinity of a vehicle, an azimuth angle of the candidate object relative to a display screen is determined based on a first position of the candidate object in a first coordinate system and a second position of the display screen in the first coordinate system.

[0032] The sentry mode is an automotive safety function. The sentry mode mainly aims at monitoring the environment in a vicinity of the vehicle and the state of the vehicle in real time using an algorithm when the vehicle is unattended, thereby protecting the vehicle from unauthorized acts such as window breaking, scratching, and collisions.

[0033] Alternatively, in the case where the sentry mode function of the vehicle is turned on, a

sentry mode operating state is automatically activated after the vehicle is locked, or activated in response to a sentry mode activation request from a user terminal. The activation of the sentry mode function refers to switching the sentry mode function from a disabled state to an enabled state, to get ready for entering the sentry mode operating state, but the sentry mode operating state is not entered yet. The specific triggering mode for entering the sentry mode operating state is not limited.

[0034] In a sentry mode means in a sentry mode operating state. In the sentry mode, whether a candidate object to be warned is present in the vicinity of the vehicle can be determined according to the sensing result of the environment in the vicinity of the vehicle. The candidate object to be warned refers to an object which has suspicious actions such as collision with the vehicle, pulling a vehicle door, beating the vehicle, gazing at a vehicle window and the like. The candidate object includes, for example, but not limited to, one or more of a pedestrian, another vehicle, a cyclist, and the like.

[0035] The first coordinate system is a unified coordinate system in which the display screen and the candidate object are located. The first coordinate system is, for example, but not limited to, a coordinate system of a preset plane of a vehicle coordinate system or a Bird's Eye View (BEV) coordinate system. The preset plane is, for example, but not limited to, a XOY plane of the vehicle coordinate system or a plane parallel to the XOY plane where the center point of the display screen is located, where X denotes a lateral direction, such as a direction perpendicular to the vehicle central axis toward the right of the vehicle; Y denotes a longitudinal direction, for example, a direction toward the rear of the vehicle along the vehicle center axis.

[0036] The first position is a position of the candidate object in the first coordinate system. Alternatively, the first position of the candidate object in the first coordinate system may be determined according to the sensing result of the candidate object. The second position is a position of the display screen in the first coordinate system, and the second position may be

obtained by pre-calibration.

[0037] The azimuth angle of the candidate object relative to the display screen refers to an included angle of a vector pointing to the candidate object from the display screen relative to a projection line of a normal of the display screen in the first coordinate system, or an included angle of a vector pointing to the candidate object from the display screen relative to a first preset direction of the first coordinate system. The first preset direction is a direction toward the rear of the vehicle along the vehicle center axis.

[0038] At step 220, a target gaze direction of a virtual interactive avatar is determined based on the azimuth angle.

[0039] The virtual interactive avatar is a virtual avatar provided for the sentry mode, and simulated with gaze capability. For example, the virtual interactive avatar may be, but is not limited to, a virtual character avatar, a virtual eye avatar, and the like.

[0040] The azimuth angle reflects a direction of the candidate object relative to the display screen, and the virtual interactive avatar is an avatar for interacting with a target object of the candidate object, that is, the virtual interactive avatar gazes at the target object to indicate that the target object has been locked by the sentry mode of the vehicle. Thus, the target gaze direction of the virtual interactive avatar may be determined based on the azimuth angle of the candidate object.

[0041] Alternatively, the target gaze direction is a direction pointing to a target object of the candidate objects from the display screen.

[0042] Alternatively, the target object may be determined from the candidate objects based on a preset rule. The preset rule is, for example, but not limited to, randomly selecting a target object from the candidate objects.

[0043] At step 230, the virtual interactive avatar based on the target gaze direction is rendered to generate a display image in which the virtual interactive avatar gazes at a target object in the

target gaze direction.

[0044] A particular visualization avatar of the virtual interactive avatar may be set according to actual requirements, and the gaze direction of the virtual interactive avatar is represented, for example, but not limited to, as a simulated light beam emitted from the virtual interactive avatar in a target gaze direction. The simulated light beam is, for example, but not limited to, a light beam having a preset color. The preset color includes, for example, but not limited to, one or more colors.

[0045] Alternatively, the virtual interactive avatar may be rendered by a rendering engine on the vehicle based on the target gaze direction, to generate a display image in which the virtual interactive avatar gazes at the target object in the target gaze direction.

[0046] Alternatively, after generating the display image, the display image can be displayed on a display screen, so that the virtual interactive avatar gazing at the target object is displayed in the display screen, for purpose of interaction between the virtual interactive avatar and the target object, and the target object can see through a vehicle window the virtual interactive avatar displayed on the display screen, so that the target object can perceive being actively tracked by the sentry mode of the vehicle, thereby producing direct psychological deterrence on the target object.

[0047] Alternatively, there may be one or more target gaze directions. In a case where there are a plurality of target gaze directions, the virtual interactive avatar can be rendered respectively based on the plurality of target gaze directions, to generate a display image in which a plurality of virtual interactive avatars gaze at target objects in different target gaze directions respectively, so as to conduct warning deterrence on a plurality of suspicious target objects simultaneously.

[0048] According to the display image generation method, an apparatus, a storage medium and a device provided by embodiments of the present disclosure, a vehicle can in a sentry mode, in response to determining that the candidate object to be warned is present in a vicinity of the

vehicle, determine an azimuth angle of the candidate object relative to the display screen based on the first position of the candidate object in the first coordinate system and the second position of the display screen in the first coordinate system; then determine the target gaze direction of the virtual interactive avatar based on the azimuth angle; and thereafter render the virtual interactive avatar based on the target gaze direction, to generate a display image in which the virtual interactive avatar gazes at the target object in the target gaze direction, so that upon observing the virtual interactive avatar gazing at the target object, the target object can perceive being actively tracked, thereby producing direct psychological deterrence on the target object, achieving a directional warning function, and effectively improving the warning effect.

[0049] FIG. 3 is a schematic flowchart of a display image generation method according to another exemplary embodiment of the present disclosure.

[0050] In some alternative embodiments, on the basis of any of the above-mentioned embodiments, as shown in FIG. 3, the method of the embodiment of the present disclosure may further include steps 310 to 330 as follows.

[0051] At step 310, a sensing result is determined based on sensor data collected by sensors on the vehicle.

[0052] The sensing result includes state information of one or more objects. The one or more objects include, for example, but are not limited to, pedestrians, riders, other vehicles, or any type or preset type of objects in the vicinity of the vehicle. The state information of the object includes, for example, but is not limited to, one or more of a position of the object in an image, a distance between the object and the vehicle, a position of a point on the object closest to the vehicle in the image, a speed at which the object approaches the vehicle, a body posture of the object, and the like.

[0053] The sensors include, but are not limited to, cameras, ultrasonic radars, millimeter wave radars, laser radars, and the like. The sensor data include, but are not limited to, image data

collected by cameras, radar data collected by various radars, and the like. The cameras may include cameras with one or more viewing angles.

[0054] Alternatively, perceptual processing may be performed on the sensor data based on a sensing function module predisposed on the vehicle, so as to obtain the sensing result. The present disclosure does not limit the specific operation of the sensing function module to determine the sensing result.

[0055] At step 320, the candidate object is determined based on the sensing result.

[0056] The sensing result can reflect a state of each object relative to the vehicle. Whether each object constitutes a risk to the vehicle can be determined based on the sensing result when any object takes risky actions toward the vehicle, the object can be designated as a candidate object. Alternatively, a condition for determining the candidate object may be preset, then the candidate object may be determined from objects in the sensing result according to the sensing result and a preset condition for determining the candidate object. Such conditions include, for example, but not limited to, an object posing a risk of collision with the vehicle, striking the vehicle, loitering in the vicinity of the vehicle for an extended period, or suddenly approaching the vehicle and gazing at its windows. When any object is present one or more of the above-mentioned risky actions, it can be designated as a candidate object.

[0057] At step 330, a first position of the candidate object in the first coordinate system is determined based on a perspective transformation matrix and a first pixel position in state information of the candidate object.

[0058] The first pixel position is a pixel position, in an image, of a point on the candidate object closest to the vehicle.

[0059] Alternatively, the first pixel position may be sensed by the sensing function module. For example, through target detecting and tracking, the pixel position in the image of the point on each sensed object closest to the vehicle is acquired and designated as the first pixel position.

When any object is designated as a candidate object, the first pixel position of the candidate object can be acquired from the state information of the candidate object.

[0060] The perspective transformation matrix is a transformation matrix from an image coordinate system of a camera on the vehicle to the first coordinate system. Cameras with different viewing angles may have respective perspective transformation matrices. For example, a front view camera, a left view camera, a right view camera, and a rear view camera correspond to different perspective transformation matrices, respectively. The perspective transformation matrix may be pre-calibrated.

[0061] Exemplarily, taking a fisheye camera as an example, intrinsic parameters and distortion parameters of the fisheye camera can be determined via a chessboard calibration. And then, for raw images captured by the fisheye camera, an undistorted processing is performed on the raw images on the basis of the intrinsic parameters and distortion parameters of the fisheye camera to obtain undistorted images. First coordinate points corresponding to a plurality of preset reference points on the chessboard in the undistorted images are determined respectively, and second coordinate points corresponding to the plurality of preset reference points in desired BEV images are determined respectively. A perspective transformation matrix M is calculated according to the first coordinate points and the second coordinate points. The desired BEV images are BEV images defined during calibration and contain all the preset reference points, which are used to calculate the perspective transformation matrix. The specific manner of determining the perspective transformation matrix is not limited to the above-mentioned exemplary manner.

[0062] Alternatively, the first pixel position may be an undistorted pixel position. The first pixel position may be transformed to the first coordinate system using the perspective transformation matrix based on the first pixel position, to obtain the first position of the candidate object. Or, the first pixel position may be a distorted pixel position. The first pixel position may be transformed to undistorted image coordinate system based on a distortion

parameter of an image acquisition camera, to obtain a second pixel position, and then the second pixel position may be transformed to the first coordinate system based on the second pixel position and the perspective transformation matrix, to obtain the first position of the candidate object.

[0063] In the embodiment of the present disclosure, the candidate object is determined based on the sensing result determined from the sensor data, so as to screen out risky suspicious objects. For the candidate object, the first position of the candidate object in the first coordinate system is determined based on the first pixel position of the candidate object closest to the vehicle and the perspective transformation matrix, thereby providing an accurate position reference for determining the azimuth angle of the candidate object.

[0064] In some alternative embodiments, determining the candidate object based on the sensing result at step 320 may include:

determining, from one or more objects, an object of which the state information satisfies a risk trigger condition, based on state information of the one or more objects in the sensing result and a preset risk trigger condition; and in response to a presence of at least one object satisfying the risk trigger condition in the one or more objects, designating the object satisfying the risk trigger condition as the candidate object.

[0065] The risk trigger condition is a condition for determining whether the object triggers a risk, that is, the risk trigger condition is a condition for determining whether the object has a risk action. Risk actions include, for example, but not limited to, one or more objects colliding with the vehicle, beating the vehicle, pulling a vehicle door, suddenly approaching the vehicle and gazing at a vehicle window, wandering in the vicinity of the vehicle for a duration exceeding a duration threshold, and the like. The specific risk trigger condition may be set according to actual requirements.

[0066] Alternatively, a position of the object, a distance between the object and the vehicle, an

orientation of the object, a speed of approaching the vehicle, a gaze direction, a body posture and other states can be determined according to the state information of the object. The states of the objects are matched with the risk trigger condition, and whether the state information of the objects satisfy the risk trigger condition are determined according to the matching result. If the state information of at least one object satisfies the risk trigger condition, the object satisfying the risk trigger condition is designated as the candidate object.

[0067] For example, when the distance of any object is detected to be less than a distance threshold, a duration during which the distance of the object is less than the distance threshold may be recorded, and if the duration during which the distance of the object from the vehicle is less than the distance threshold exceeds a duration threshold, indicating that the object wanders in the vicinity of the vehicle for a longer time, which may be a risk, and therefore the object may be designated as the candidate object.

[0068] For example, the object is determined to approach the vehicle suddenly according to the sudden increase of the speed of the object approaching the vehicle, and the object is determined to gaze at the vehicle window according to the eye position and the gaze direction of the object, it indicates that the object is observing the inside of the vehicle, the action is suspicious, a certain risk exists, and the object can be designated as the candidate object.

[0069] For example, the object may be determined to be pulling the vehicle door based on the distance between the object and the vehicle being 0 or close to 0, in combination with the position of the closest point on the object to the vehicle being close to the handle of the vehicle door; or the position of the closest point is the vehicle window, it is determined that the object is beating the window. Or, in combination with the vibration of the vehicle, the vehicle door or the vehicle window, the object is determined to be beating the vehicle, the vehicle door, the vehicle window, and the like.

[0070] In practical applications, the specific operation of determining whether the state

information of the object satisfies the risk trigger condition is not limited to the above-described example.

[0071] In the embodiment of the present disclosure, based on the sensed state information of the object, a suspicious object determined from the objects is designated as the candidate object through a preset risk trigger condition, which excludes objects apparently without risk, thereby effectively improving the accuracy and validity of the candidate object.

[0072] In some alternative embodiments, the method of the embodiment of the present disclosure may further include:

in response to the presence of at least one object satisfying the risk trigger condition in the one or more objects, controlling the display screen to be switched from a first preset state to a first warning state; after generating the display image, displaying the display image on the display screen, or in response to an absence of an object satisfying the risk trigger condition in the one or more objects, controlling the display screen to maintain the first preset state.

[0073] The first preset state is, for example, but not limited to, an always-off state, that is, after entering the sentry mode operating state, if no suspicious object is present in the vicinity of the vehicle, the display screen may be in the always-off state to conserve power. The first warning state is a state of displaying a warning mode interface. When at least one object satisfying the risk trigger condition is present in the vicinity of the vehicle, it indicates that a suspicious object is present in the vicinity of the vehicle, the display screen is controlled to be switched from the first preset state to the first warning state, to prepare for displaying a warning image. After the display image in which the virtual interactive avatar gazes at the target object is generated, the display image may be displayed on the display screen to warn the target object.

[0074] If an absence of an object satisfying the risk trigger condition in the sensed objects, it indicates that the suspicious object is absent in the vicinity of the vehicle, the display screen is controlled to maintain the first preset state, to reduce power consumption, and conserve electric

power.

[0075] In the embodiment of the present disclosure, when it is determined that at least one object satisfying the risk trigger condition is present in the vicinity of the vehicle, the display screen is controlled to be switched from the first preset state to the first warning state in time, so that after the display image in which the virtual interactive avatar gazes at the target object is generated, the display image can be displayed on the display screen in time to warn the target object. When the object satisfying the risk trigger condition is absent in the vicinity of the vehicle, the display screen is kept in the first preset state, to reduce power consumption, and save electric power.

[0076] FIG. 4 is a schematic flowchart of a display image generation method according to yet another exemplary embodiment of the present disclosure.

[0077] In some alternative embodiments, on the basis of any of the above embodiments, the first coordinate system is a two-dimensional coordinate system for a preset plane of a vehicle coordinate system.

[0078] As shown in FIG. 4, the azimuth angle of the candidate object relative to the display screen is determined based on the first position of the candidate object in the first coordinate system and the second position of the display screen in the first coordinate system at step 210, which may include steps 2110-2120.

[0079] At step 2110, a first included angle between a line segment connecting the first position and the second position and a first preset direction in the first coordinate system is determined based on the first position and the second position.

[0080] The first preset direction is a direction of a projection line of a normal of the display screen on a preset plane.

[0081] The first included angle is the included angle between the line segment connecting the first position and the second position and the first preset direction in the first coordinate system.

Alternatively, a vector pointing from the first position to the second position may be determined based on the first position and the second position, and the first included angle may be determined based on the vector and a direction vector of the first preset direction. Or, a line segment connecting the first position and the second position is determined based on the first position and the second position, and the first included angle is determined based on an included angle between the line segment and a line segment in the first preset direction. The specific means of calculating the first included angle is not limited.

[0082] In some alternative embodiments, in a case where the direction of the projection line of the normal of the display screen on the preset plane is a Y direction of the first coordinate system, the first preset direction is the Y direction. The first included angle may be calculated by an arctangent function based on the first position and the second position.

[0083] At step 2120, the first included angle is designated as the azimuth angle of the candidate object relative to the display screen.

[0084] After the first included angle is determined, the first included angle may be designated as the azimuth angle of the candidate object relative to the display screen.

[0085] In some alternative examples, FIG. 5 is a schematic diagram of a calculation principle of an azimuth angle of a candidate object according to an exemplary embodiment of the present disclosure. As shown in FIG. 5, the first coordinate system is designated as an example of the XOY plane of the vehicle coordinate system, where the positive direction X is vertical to the vehicle central axis to the right, and the positive direction Y is rearward along the vehicle central axis. The second position of the display screen 13 is a position T2(xt, yt) of the center point of the display screen 13 in the first coordinate system, the first position of the candidate object in the first coordinate system is P2(x2, y2), the first preset direction is the Y direction, and the azimuth angle can be expressed as follows:

$$\text{azimuth} = \arctan((x2 - xt)/(y2 - yt)) \quad \text{Formula (1)}$$

where $\arctan()$ represents an arctangent function, and azimuth represents an azimuth angle, or horizontal angle.

[0086] In the embodiment of the present disclosure, based on the first position of the candidate object in the first coordinate system and the second position of the display screen in the first coordinate system, the included angle between the line segment connecting the first position and the second position and the first preset direction is determined as the azimuth angle of the candidate object, so that the azimuth angle of the candidate object can be accurately calculated, and accurate and effective azimuth reference can be provided for determining the target gaze direction of the virtual interactive avatar.

[0087] FIG. 6 is a schematic flowchart of a display image generation method according to still another exemplary embodiment of the present disclosure.

[0088] In some alternative embodiments, on the basis of any of the above embodiments, as shown in FIG. 6, a target gaze direction of a virtual interactive avatar is determined based on the azimuth angle at the step 220 may include steps 2210 to 2220 as follows.

[0089] At step 2210, a target object from the candidate object is determined based on the azimuth angle and a preset angle range.

[0090] The preset angle range is an angle range preset according to a visible range of the display screen. The preset angle range may be less than or equal to the visible range of the display screen. The visible range of the display screen refers to a range in which an object outside the vehicle can see the display screen, or a range in which a virtual interactive avatar displayed on the display screen can see in a simulated manner, that is, a viewing angle range that the virtual interactive avatar can see outside from the display screen.

[0091] Exemplarily, the first preset direction is a 0° direction, and the preset angle range is, for example, but not limited to, $[-S1^\circ, S2^\circ]$. $S1$ and $S2$ are both positive numbers. $S1$ and $S2$ may be the same or different. For example, $[-S1^\circ, S2^\circ] = [-75^\circ, 75^\circ]$, $[-80^\circ, 75^\circ]$ and the like.

[0092] Alternatively, the target object may be determined from the candidate object according to whether the azimuth angle of the candidate object is within the preset angle range. For example, a candidate object having an azimuth angle within the preset angle range is designated as the target object. This is because a candidate object that is not within the preset angle range cannot see the display screen, and thus cannot be frightened by the virtual interactive avatar. Therefore, one or more candidate objects within the preset angle range is designated as the target object, thereby improving validity of the target object.

[0093] At step 2220, the target gaze direction of the virtual interactive avatar is determined based on the azimuth angle of the target object.

[0094] After the target object is determined, the target gaze direction of the virtual interactive avatar is determined based on the azimuth angle of the target object, such that the virtual interactive avatar gazes at the target object along the target gaze direction, and interacts with the target object to alert the target object.

[0095] Alternatively, a mapping relationship between the azimuth angle and the gaze direction is pre-established. Based on the azimuth angle of the target object, the azimuth angle is mapped to the target gaze direction of the virtual interactive avatar via the mapping relationship.

[0096] Alternatively, the virtual interactive avatar has a corresponding avatar model. The avatar model is, for example, but not limited to, a three-dimensional model in a preset three-dimensional space, for example, but not limited to, a virtual three-dimensional space for rendering. The target gaze direction represents the orientation of the avatar model. The avatar model is observed by a virtual camera for rendering in the preset three-dimensional space, the avatar model is mapped to an image coordinate system of the virtual camera, a mapping relationship is provided between the image coordinate system of the virtual camera and a display interface of the display screen, and an image generated by the virtual camera is displayed on the display interface of the display screen as a display image, to implement the rendering and image

display of the virtual interactive avatar.

[0097] In some alternative embodiments, the target object from the candidate object is determined based on the azimuth angle and a preset angle range at the step 2210 may include:

in response to, among the candidate objects, only one candidate object (called a first candidate object) having an azimuth angle within the preset angle range, designating the first candidate object as the target object; or in response to, among the candidate objects, a plurality of candidate objects having azimuth angles (called second candidate objects) within the preset angle range, according to candidate durations of the plurality of second candidate objects, designating a second candidate object with the longest candidate duration as the target object. The candidate duration is a duration during which the second candidate object belongs to the candidate object to be warned.

[0098] If only one first candidate object has an azimuth angle within the preset angle range, only the first candidate object sees the display screen. Therefore, the first candidate object is designated as the target object.

[0099] If a plurality of second candidate objects in the candidate objects have azimuth angles within the preset angle range, a target object most in need of alert is further screened from the plurality of second candidate objects. The candidate duration refers to a duration during which the second candidate object is determined as the candidate object. For example, after a object is determined as the candidate object for the first time, the candidate duration of the candidate object is maintained in real time. When the target object needs to be determined from a plurality of second candidate objects, the second candidate object with the longest candidate duration is designated as the target object according to the candidate durations of the plurality of second candidate objects. The longest candidate duration indicates that the second candidate object is more suspicious, so that a prompt warning is more necessary.

[00100] In some alternative embodiments, FIG. 7 is a schematic diagram of a determination of a

target object from candidate objects according to an exemplary embodiment of the present disclosure. As shown in FIG. 7, in the BEV coordinate system (i.e., the first coordinate system), the Y direction is defined as the 0° direction. A 360° angle centered on the display screen center or its projection point on a preset plane is defined as a range of $[-180^\circ, 180^\circ]$, with a preset angle range of $[-75^\circ, 75^\circ]$. Candidate objects include candidate object A, candidate object B, and candidate object C, where the candidate object A has the azimuth angle greater than 75° , the candidate object B has the azimuth angle less than -75° , and the candidate object C has the azimuth angle falling within a range of $[-75^\circ, 75^\circ]$. The virtual interactive avatar displayed on the display screen can be seen by the candidate object C, and cannot be seen by the candidate object A and the candidate object B, thereby designating the candidate object C as the target object.

[00101] According to the embodiment of the present disclosure, a candidate object capable of seeing the display screen is selected from the suspicious candidate objects as the target object according to the preset angle range, further improving the validity of the target object. When the plurality of second candidate objects, among the candidate objects, have azimuth angles within the preset angle range, the second candidate object having the longest candidate duration is designated as the target object based on the candidate duration of the second candidate object, which improve the validity of the target object, realize targeted warning toward the higher-risk target objects, thereby improving the warning effect.

[00102] In some alternative embodiments, the target gaze direction of the virtual interactive avatar is determined based on the azimuth angle in step 220 further include:

in response to a failure to determine the target object based on the azimuth angle and the preset angle range, determining the target gaze direction of the virtual interactive avatar to be a second preset direction.

[00103] The second preset direction may be set according to actual requirements. For example, the second preset direction may be a gaze direction corresponding to the preset azimuth angle

within the visible range of the display screen. The preset azimuth angle is, for example, but not limited to, 0° or other azimuth angles.

[00104] Alternatively, the second preset direction may be, but is not limited to, a direct front of the display screen. That is, the avatar model of the virtual interactive avatar gazes at the virtual camera for rendering, so that the rendered display image presents an effect of gazing at the direct front of the display screen on the display screen. In this case, since no suspicious target object is present within the visible range of the display screen, the target object gazed by the virtual interactive avatar refers to any object along the target gaze direction. For example, the target object gazed by the virtual interactive avatar may be a portion inside the vehicle positioned on the target gaze direction.

[00105] Exemplarily, FIG. 8 is a schematic diagram of a visualization of a virtual interactive avatar according to an exemplary embodiment of the present disclosure. As shown in FIG. 8, a schematic diagram of different gaze directions of a virtual interactive avatar is shown. In the left display screen, the virtual interactive avatar gazes at the direct front of the display screen. In the right display screen, the virtual interactive avatar gazes at the right front of the display screen, and dashed arrows represents light beams emitted by the virtual interactive avatar along the gaze direction. It should be noted that FIG. 8 is only an exemplary illustration of the gaze direction of the virtual interactive avatar, and is not a limitation on the display image. In practical applications, the display image displayed on the display screen may further include a background image, a gaze light beam with a specific color and effect, and the like. The specific virtual interactive avatar is not limited to the virtual eyeball in FIG. 8.

[00106] In the embodiment of the present disclosure, when no candidate object is present within the visible range of the display screen and a candidate object is present outside the visible range, the target gaze direction of the virtual interactive avatar is determined to be the second preset direction, so that a display image in which the virtual interactive avatar gazes at the target gaze

direction can be generated, for the convenience of seeing by the vehicle user.

[00107] In some alternative embodiments, on the basis of any of the above embodiments, the virtual interactive avatar is rendered based on the target gaze direction, to generate a display image in which the virtual interactive avatar gazes at a target object in the target gaze direction at step 230, may include:

rendering to generate a dynamic display image in which a gaze light beam is emitted from the virtual interactive avatar and flickers according to a preset rule, based on the target gaze direction and an avatar model of the virtual interactive avatar.

[00108] The avatar model of the virtual interactive avatar may be, but is not limited to, the three-dimensional model of the preset three-dimensional space. The three-dimensional space is, for example, but not limited to, a virtual three-dimensional space. The avatar model is positioned in the three-dimensional space according to a preset initial gaze direction. After the target gaze direction is determined, the virtual interactive avatar is rendered based on the target gaze direction, and the display image in which the virtual interactive avatar gazes at the target object in the target gaze direction is generated.

[00109] Alternatively, the avatar model may be rotated according to the target gaze direction and the initial gaze direction of the avatar model, such that the gaze direction of the avatar model rotates to the target gaze direction. The avatar model is mapped to the image coordinate system of the virtual camera based on intrinsic parameters and extrinsic parameters of the virtual camera in the three-dimensional space, to generate a layer of the virtual interactive avatar. According to the layer of the virtual interactive avatar and the background layer, layer fusion is performed to obtain a display image. In the process of generating the layer of the virtual interactive avatar, a gaze light beam emitted from the virtual interactive avatar and flickers according to a preset rule is generated according to the target gaze direction of the virtual interactive avatar, so that a dynamic layer of the virtual interactive avatar is generated. A dynamic display image is

generated according to the dynamic layer of the virtual interactive avatar and a dynamic background layer. Alternatively, the background layer may be a static background layer or a dynamic background layer, which is not limited in detail. The dynamic effect of the dynamic display image is realized by dynamic update of the display image. For example, the gaze light beam flickering according to a preset rule refers to dynamically updating the display effect of the gaze light beam in the display image according to the preset rule. For example, brightness and/or color of the gaze light beam changes at a preset frame interval, such as the brightness and/or color changes once every 3 frames, so as to achieve the flicker effect. The specific operation of dynamically updating the display image is not described again.

[00110] Exemplarily, FIG. 9 is a schematic diagram of a display effect of a display image according to an exemplary embodiment of the present disclosure. As shown in FIG. 9, the display image includes the virtual interactive avatar and the background image. The gaze light beam is emitted from an eye of the virtual interactive avatar. Alternatively, the gaze light beam may be a light beam having a specified brightness and/or color. Alternatively, the gaze light beam may be a light beam of a single color or a combination of multiple colors. For example, the gaze light beam may be, but is not limited to, a red, a yellow, a green, and the like. The flicker effect may be an effect of a change in brightness and color.

[00111] In the embodiment of the present disclosure, based on the target gaze direction and the avatar model of the virtual interactive avatar, rendering is made to generate a dynamic display image in which a gaze light beam is emitted from the virtual interactive avatar and flickers according to a preset rule, which improve the effect of the virtual interactive avatar gazing at the target object, so that the target object can more easily sense locking by the sentry mode of the vehicle, and enhances warning effect.

[00112] FIG. 10 is a schematic flowchart of a display image generation method according to yet another exemplary embodiment of the present disclosure.

[00113] In some alternative embodiments, on the basis of any of the above embodiments, as shown in FIG. 10, after generating the display image, steps 240 to 250 may further be included.

[00114] At step 240, in response to a change in the azimuth angle of the target object from a first azimuth angle to a second azimuth angle, a rotation trajectory of the virtual interactive avatar based on the first azimuth angle and the second azimuth angle is determined.

[00115] The first azimuth angle may be an azimuth angle of the target object calculated by the above embodiment. The second azimuth angle is an azimuth angle different from the first azimuth angle. After generating the display image, the state information of the target object may be continuously monitored according to the steps of the above-embodiments, and the azimuth angle of the target object may be determined. When determining that the azimuth angle of the target object changes from the first azimuth angle to the second azimuth angle, it indicates a change in the azimuth angle of the target object relative to the display screen. To enable the virtual interactive avatar to track and lock onto the target object, the rotation trajectory of the virtual interactive avatar may be determined based on the first azimuth angle and the second azimuth angle.

[00116] Alternatively, the rotation trajectory of the virtual interactive avatar may be determined according to an angle change of the gaze direction corresponding to the second azimuth angle relative to the gaze direction corresponding to the first azimuth angle. The rotation trajectory may include, but is not limited to, the number of frames for rotating the avatar model of the virtual interactive avatar, and the rotation angle and rotation direction per frame. That is, the virtual interactive avatar rotates over one or more frames from the gaze direction corresponding to the first azimuth angle to the gaze direction corresponding to the second azimuth angle.

[00117] At step 250, the virtual interactive avatar is rendered based on the rotation trajectory, to generate a dynamic display image in which the gaze direction of the virtual interactive avatar changes along the rotation trajectory.

[00118] The rotation trajectory includes the number of target frames needed for the virtual interactive avatar to rotate as well as the rotation angle and the rotation direction per frame. The number of target frames may be one or more frames. Each frame of rotation corresponds to one intermediate gaze direction, and an intermediate display image is generated. For example, the change from the gaze direction corresponding to the first azimuth angle to the gaze direction corresponding to the second azimuth angle is realized by n rotations, each with a small angle. Starting from the gaze direction corresponding to the first azimuth angle, once rotation obtains an updated gaze direction, rendering based on the updated gaze direction generates an intermediate display image, which is displayed by the display screen. Meanwhile, in the display process, the gaze direction is updated by continuous rotations, and a new intermediate display image is generated via rendering and displayed. And so on, until the gaze direction corresponding to the second azimuth angle is reached. Rendering may then continue according to the gaze direction of the target object or the next target object.

[00119] Alternatively, in a case where the azimuth angle of the target object changes from the first azimuth angle to the second azimuth angle, it is further determined whether the second azimuth angle is within the preset angle range. If the second azimuth angle is within the preset angle range, a rotation trajectory of the virtual interactive avatar is determined based on the first azimuth angle and the second azimuth angle, and the virtual interactive avatar is rendered based on the rotation trajectory, to generate a dynamic display image in which the gaze direction of the virtual interactive avatar changes along the rotation trajectory. If the second azimuth angle is not within the preset angle range, the target object is re-determined according to the above process of determining the target object. Or the target object is continuously monitored for the preset duration, and if the target object is determined to leave the visible range of the display screen, then the target object is re-determined.

[00120] Alternatively, in a case where the azimuth angle of the target object changes from the

first azimuth angle to the second azimuth angle, it is further determined whether the target object is still a suspicious candidate object, that is, whether the target object still has a risk action. If the target object is determined to have no risk action or the target object has no risk action for a continuous preset duration, the target object is re-determined. Or, if the target object is still a suspicious candidate object and is still within the preset angle range, a rotation trajectory of the virtual interactive avatar is determined based on the first azimuth angle and the second azimuth angle, and the virtual interactive avatar is rendered based on the rotation trajectory, to generate a dynamic display image in which the gaze direction of the virtual interactive avatar changes along the rotation trajectory.

[00121] According to the embodiment of the present disclosure, when the azimuth angle of the target object changes, the rotation trajectory of the virtual interactive avatar is determined according to the change in the azimuth angle of the target object. The virtual interactive avatar is rendered according to the rotation trajectory, to generate a dynamic display image in which the gaze direction of the virtual interactive avatar changes along the rotation trajectory, so that the dynamic display image is displayed on the display screen, presenting the effect of the gaze direction of the virtual interactive avatar tracking and locking onto the target object, further improving the deterrence force on the target object, and further improving the warning effect.

[00122] In some alternative embodiments, display images with different azimuth angles may be rendered, generated and cached for respective azimuth angles in advance. After the target object is determined, in the process of rendering, the display image corresponding to the azimuth angle of the target object may be directly acquired from the cached display images, according to the azimuth angle of the target object for display, or the display image changing along the azimuth angle is displayed according to a preset frame rate based on the change in the azimuth angle of the target object, so as to obtain a dynamic display image effect, to reduce display delay and improve display efficiency.

[00123] FIG. 11 is a schematic flowchart of a display image generation method according to still another exemplary embodiment of the present disclosure.

[00124] In some alternative embodiments, on the basis of any of the above embodiments, as shown in FIG. 11, after generating the display image, the method of the embodiment of the present disclosure may further include steps 410 to 420.

[00125] At step 410, by taking the target object is designated as a tracked object, and the gaze direction of the virtual interactive avatar in the display image is controlled to rotate with changes in the azimuth angle of the target object.

[00126] The tracked object refers to an object that is tracked and locked along the gaze direction of the virtual interactive avatar. Alternatively, by rotating the avatar model of the virtual interactive avatar, the image is rendered according to the rotated avatar model, so as to achieve the effect that the gaze direction of the virtual interactive avatar in the display image rotates with the change in the azimuth angle of the target object. The specific rotation principle refers to the foregoing embodiment.

[00127] Alternatively, after the target object is determined, the target object may be tracked for at least a first duration, such as, but not limited to, 2 seconds or other duration. If the azimuth angle of the target object is continuously within the preset angle range and the target object is continuously a suspicious candidate object, the gaze direction of the virtual interactive avatar in the display image is controlled to rotate with the change in the azimuth angle of the target object.

[00128] At step 420, in response to a change in the target object from the tracked object to an untracked object within a first duration, maintaining the gaze direction of the virtual interactive avatar in the display image at a first gaze direction in a last frame before the target object becomes the untracked object.

[00129] The untracked object refers to an object for which the virtual interactive avatar temporarily does not need to track and lock.

[00130] Alternatively, if the target object leaves the preset angle range or becomes a non-suspicious object within the first duration, it is determined that the target object changes from the tracked object to the untracked object within the first duration, a tracking action of the virtual interactive avatar may be suspended, and the gaze direction of the virtual interactive avatar in the display image is maintained as the first gaze direction of the last frame before the target object becomes the untracked object. For example, maintaining the gaze direction of the last frame before the target object leaves the preset angle range or becomes a non-suspicious object. The state information of the target object can be continuously tracked to determine whether it is necessary to terminate the tracking of the target object, and re-determine the target object, or in the absence of a target object, end the tracking state of the sentry mode.

[00131] In the embodiment of the present disclosure, after the target object is determined, the target object is designated as a tracked object, the gaze direction of the virtual interactive avatar in the display image is controlled to rotate with the change in the azimuth angle of the target object, so that the target object is tracked and locked, which is more favorable for the target object to determine that it is locked onto, further improving the warning effect.

[00132] In some alternative embodiments, as shown in FIG. 11, the method of the embodiment of the present disclosure also includes steps 430-460.

[00133] At step 430, in response to the target object becoming the tracked object again within a second duration after becoming the untracked object, a current gaze direction of the virtual interactive avatar is determined based on a current azimuth angle of the target object.

[00134] The second duration may be set according to actual requirements, and the second duration is, for example, but not limited to, 2 seconds or other duration.

[00135] If the target object becomes the tracked object again within the second duration after becoming the untracked object. For example, if the target object has a risk action and the azimuth angle of the target object enters the preset angle range again, the target object is continuously

tracked and warned, and the current gaze direction of the virtual interactive avatar is determined based on the current azimuth angle of the target object.

[00136] At step 440, a dynamic display image in which the virtual interactive avatar rotates from the first gaze direction to the current gaze direction is generated according to the first gaze direction and the current gaze direction.

[00137] The first gaze direction is a gaze direction of a last frame before the target object becomes an untracked object. Since the target object becomes to an untracked object in a period of time, its azimuth angle changes, the current gaze direction may be different from the first gaze direction. A dynamic display image in which the virtual interactive avatar rotates from the first gaze direction to the current gaze direction is generated based on the first gaze direction and the current gaze direction, thereby ensuring that the virtual interactive avatar moves naturally and slowly in a non-linear manner.

[00138] Alternatively, the virtual interactive avatar may be rendered according to a rotation trajectory from the first gaze direction to the current gaze direction, to generate a dynamic display image in which the virtual interactive avatar rotates from the first gaze direction to the current gaze direction.

[00139] At step 450, the dynamic display image is displayed by the display screen.

[00140] The dynamic display image includes a plurality of frames of the display image. The effect of the dynamic display image is realized by sequentially displaying the plurality of frames of the display image on the display screen.

[00141] Alternatively, the display image may be displayed on the display screen for each generated frame, and the dynamic refreshing of the display image on the display screen achieves the effect of the dynamic display image.

[00142] At step 460, in response to the target object failing to become the tracked object within a second duration after becoming the untracked object, the display image is updated to a display

image in which the gaze direction of the virtual interactive avatar is a target direction.

[00143] The target direction is a second preset direction or a second gaze direction corresponding to the azimuth angle of the next target object.

[00144] Alternatively, if the target object fails to become the tracked object within a second duration after becoming the untracked object, it indicates that the target object has been risk-relieved or has left the visible range of the display screen. The target object can be re-determined according to the above method of determining the target object. If the next target object is determined, the second gaze direction corresponding to the azimuth angle of the next target object is designated as the target direction, rendering is made according to the target direction to generate a display image in which the virtual interactive avatar gazes at the target object in the target direction, the display screen is updated, and the display image is displayed on a display screen, so that the virtual interactive avatar gazes at a new target object, thereby warning the new target object

[00145] If the next target object cannot be determined and a suspicious candidate object still is present, the second preset direction is designated as the target direction, and the display image is updated to a display image in which the gaze direction of the virtual interactive avatar is the target direction.

[00146] In the embodiment of the present disclosure, in a case where the target object becomes the tracked object again within the second duration after becoming the untracked object, it continues to track the target object, and the current gaze direction of the virtual interactive avatar is determined based on the current azimuth angle of the target object. The dynamic display image in which the virtual interactive avatar rotates from the first gaze direction to the current gaze direction is generated based on the first gaze direction and the current gaze direction. It is beneficial to improve the motion continuity of the virtual interactive avatar, ensuring that the virtual interactive avatar moves naturally and slowly in a non-linear manner, thereby improving

the visual effect of the display image.

[00147] In some alternative embodiments, on the basis of any of the above embodiments, the method of the embodiment of the present disclosure may further include:

generating warning audio for the candidate object according to the azimuth angle; and playing the warning audio by a sound playing device on the vehicle.

[00148] The warning audio for the candidate object refers to the warning audio includes the azimuth information of the candidate object, thereby playing the directional warning audio by the sound player, such that the candidate object can know that it is locked by the vehicle sentry mode in time according to the warning audio, thereby improving the warning effect. The problem that the virtual interactive avatar displayed on the display screen cannot be seen by a suspicious object outside the visible range of the real screen and thus cannot achieve the warning effect can be solved, thereby expanding the warning range. Moreover, the warning audio has azimuth directivity, which can avoid or reduce the condition that a non-suspicious object mistakenly thinks that it is warned.

[00149] For example, the content of the warning audio is, but not limited to, "sir on the front left, please keep away from the vehicle", "lady on the right, please do not tap the vehicle window", etc. The targeted voice warning is performed on the candidate object in conjunction with object attributes such as gender and age, and the azimuth angle. For object attributes such as gender and age, it is implemented by corresponding detection models or recognition models, and are not limited in the embodiments of the present disclosure.

[00150] In some alternative embodiments, light warning for the candidate object also is performed in conjunction with the azimuth angle of the candidate object and vehicle lights on the vehicle.

[00151] In some alternative embodiments, a rotatable angle range of the virtual interactive avatar may be limited, and the rotatable angle range may be less than or equal to the preset angle

range. For example, the preset angle range is $[-75^\circ, 75^\circ]$, and the rotatable angle range of the virtual interactive avatar is $[-60^\circ, 60^\circ]$. The specific rotatable angle range can be set according to actual requirements, and is not limited in the embodiments of the present disclosure.

[00152] In some alternative embodiments, the sentry mode operating state may include a sleep state, a tracking state, and a default state. In a case where no suspicious candidate object is present in the vicinity of the vehicle, the sentry mode operating state is in a sleep state, no display image needs to be rendered and the display screen is turned off, that is the display screen is in a normally dark always-off state.

[00153] Alternatively, in the sleep state, the rendering engine may prepare layer resources for the warning interface. The layer resources are, for example, but not limited to, avatar models and maps of virtual interactive avatar, warning background images, and the like.

[00154] When it is monitored that a candidate object appears in a vicinity of the vehicle, risk trigger condition is satisfied, the display screen is controlled to be switched to the warning interface. The display screen is lightened and displays the warning interface. It is determined to enter the default state or the tracking state according to whether any target object among the candidate objects is present within the visible range of the display screen.

[00155] If no target object is present among the candidate objects, the default state is entered. In the default state, the target gaze direction of the virtual interactive avatar is the second preset direction. According to the second preset direction, rendering is made to generate a display image in which the virtual interactive avatar gazes at the second preset direction, or generate a display image in which the gaze light beam is emitted from the virtual interactive avatar along the second preset direction, or generate a dynamic display image in which the gaze light beam is emitted from the virtual interactive avatar along the second preset direction and flickers according to a preset rule. The display image is displayed on the display screen.

[00156] If a target object is present among the candidate objects, the tracking state is entered.

According to the tracking process in the above embodiment, a dynamic display image in which the gaze direction of the virtual interactive avatar changes with the azimuth angle of the target object is generated, so as to achieve the effect of tracking and locking the target object, where the tracking process includes, for example, but not limited to, the above steps 410 to 460, which are not described in detail. In the default state or the tracking state, in response to the candidate object becoming a non-candidate object, that is, no candidate object is present in the vicinity of the vehicle, the sleep state is switched to save power.

[00157] The sleep state refers to the first preset state described above, and the default state and the tracking state are both warning states. For example, the default state may be the first warning state described above. The tracking state may be a second warning state. The setting of the specific state is not limited.

[00158] Alternatively, in the tracking state, the gaze light beam emitted by the virtual interactive avatar may also flicker according to a preset rule, to improve the warning effect.

[00159] In some alternative embodiments, the azimuth angle of the candidate object or target object may be updated according to a preset period, so as to provide a continuous azimuth angle input for the generation of subsequent display images. The preset period can be set according to actual requirements. Alternatively, the preset period is, for example, but not limited to, a period within 100ms to 300 ms.

[00160] In the technical solution of the present disclosure, the involved processes of collecting, storing, using, processing, transmitting, providing, and disclosing of the personal information of users all accord with the provisions of related laws and regulations, and do not violate the common customs of public order. In addition, in the technical solution of the present disclosure, the involved collection and use of the personal information of the users do not relate to illegal collection and illegal use of the personal information of the users.

[00161] The method of any embodiment of the present disclosure may be implemented alone,

or may be implemented in combination in any combination manner without conflict, which may be specifically set according to actual requirements, and is not limited in the present disclosure.

[00162] Any display image generation method provided by the embodiments of the present disclosure may be executed by any suitable device with data processing capability, including but not limited to: a terminal device, a server, software and hardware in the terminal device, software and hardware in the server and the like. Alternatively, any display image generation method provided by the embodiments of the present disclosure may be executed by a processor, for example, the processor executes any display image generation method mentioned in the embodiments of the present disclosure by calling corresponding instructions stored in a memory. Alternatively, any display image generation method provided by the embodiments of the present disclosure may also be executed by corresponding modules and units included in the following exemplary apparatus run by a processor.

Exemplary Apparatus

[00163] FIG. 12 is a schematic diagram of a structure of a display image generation apparatus according to an exemplary embodiment of the present disclosure. The display image generation device in the embodiment of the present disclosure may be used to implement the display image generation method in any of the above-mentioned embodiments of the present disclosure. The apparatus as shown in FIG. 12 may include: a first processing module 51, a second processing module 52 and a third processing module 53.

[00164] The first processing module 51 is configured to in a sentry mode, in response to determining that a candidate object to be warned is present in a vicinity of the vehicle, determine an azimuth angle of the candidate object relative to a display screen based on a first position of the candidate object in a first coordinate system and a second position of the display screen in the first coordinate system.

[00165] The second processing module 52 is configured to determine a target gaze direction of a virtual interactive avatar based on the azimuth angle.

[00166] The third processing module 53 is configured to render the virtual interactive avatar based on the target gaze direction, to generate a display image in which the virtual interactive avatar gazes at a target object in the target gaze direction.

[00167] FIG. 13 is a schematic diagram of a structure of a display image generation apparatus according to another exemplary embodiment of the present disclosure.

[00168] In some alternative embodiments, on the basis of any of the above embodiments, as shown in FIG. 13, the apparatus of the embodiment of the present disclosure may further include: a fourth processing module 54, a fifth processing module 55 and a sixth processing module 56.

[00169] The fourth processing module 54 is configured to determine a sensing result based on sensor data collected by sensors on the vehicle.

[00170] The sensing result includes state information of one or more objects.

[00171] The fifth processing module 55 is configured to determine the candidate object based on the sensing result.

[00172] The sixth processing module 56 is configured to determine the first position of the candidate object in the first coordinate system, based on a perspective transformation matrix and a first pixel position in state information of the candidate object, the first pixel position being a pixel position corresponding to a point on the candidate object closest to the vehicle.

[00173] In some alternative embodiments, the fifth processing module 55 is specifically configured to:

determine, from one or more objects, an object of which the state information satisfies the risk trigger condition based on the state information of the one or more objects in the sensing result and a preset risk trigger condition; and in response to a presence of at least one object satisfying the risk trigger condition in the one or more objects, designate the object meeting the

risk trigger condition as the candidate object.

[00174] In some alternative embodiments, as shown in FIG. 13, the apparatus of the embodiment of the present disclosure may further include:

a first control module 57 configured to in response to the presence of at least one object satisfying the risk trigger condition in the one or more objects, control the display screen to be switched from a first preset state to a first warning state; after generating the display image, display the display image on the display screen; or in response to an absence of an object satisfying the risk trigger condition in the one or more objects, control the display screen to maintain the first preset state.

[00175] In some alternative embodiments, on the basis of any of the above embodiments, the first coordinate system is a two-dimensional coordinate system for a preset plane of a vehicle coordinate system. The first processing module 51 is specifically configured to:

determine a first included angle between a line segment connecting the first position and the second position and a first preset direction in the first coordinate system based on the first position and the second position, where the first preset direction is a direction of a projection line of a normal of the display screen on a preset plane; and designate the first included angle as the azimuth angle of the candidate object relative to the display screen.

[00176] FIG. 14 is a schematic diagram of a structure of a display image generation apparatus according to still another exemplary embodiment of the present disclosure.

[00177] In some alternative embodiments, on the basis of any of the above embodiments, as shown in FIG. 14, the second processing module 52 may include: a first processing unit 521 and a second processing unit 522.

[00178] The first processing unit 521 is configured to determine the target object from the candidate object based on the azimuth angle and a preset angle range.

[00179] The second processing unit 522 is configured to determine the target gaze direction of

the virtual interactive avatar based on an azimuth angle of the target object.

[00180] In some alternative embodiments, the first processing unit 521 is specifically configured to:

in response to, among the candidate objects, only one first candidate object having an azimuth angle within the preset angle range, designate the first candidate object as the target object; or in response to, among the candidate objects, a plurality of second candidate objects having azimuth angles within the preset angle range, according to candidate durations of the plurality of second candidate objects, designate a second candidate object having the longest candidate duration as the target object, where the candidate duration is a duration during which the second candidate object belongs to the candidate object to be warned.

[00181] In some alternative embodiments, the second processing unit 522 may further be configured to:

in response to a failure to determine the target object based on the azimuth angle and the preset angle range, determine the target gaze direction of the virtual interactive avatar to be a second preset direction.

[00182] In some alternative embodiments, on the basis of any of the above embodiments, the third processing module 53 is specifically configured to:

render to generate a dynamic display image in which a gaze light beam is emitted from the virtual interactive avatar and flickers according to a preset rule, based on the target gaze direction and an avatar model of the virtual interactive avatar.

[00183] In some alternative embodiments, on the basis of any of the above embodiments, the third processing module 53 may be further configured to:

in response to a change in the azimuth angle of the target object from a first azimuth angle to a second azimuth angle, determine a rotation trajectory of the virtual interactive avatar based on the first azimuth angle and the second azimuth angle; and render the virtual interactive avatar

based on the rotation trajectory, to generate a dynamic display image in which the gaze direction of the virtual interactive avatar changes along the rotation trajectory.

[00184] In some alternative embodiments, on the basis of any of the above embodiments, the third processing module 53 is further configured to:

designate the target object as a tracked object, and control the gaze direction of the virtual interactive avatar in the display image to rotate with changes in the azimuth angle of the target object; and in response to a change in the target object from the tracked object to an untracked object within a first duration, maintain the gaze direction of the virtual interactive avatar in the display image at a first gaze direction in a last frame before the target object becomes the untracked object.

[00185] In some alternative embodiments, the apparatus of the embodiment of the present disclosure may further include a first control module 57. The second processing module 52 is further configured to in response to the target object becoming the tracked object again within a second duration after becoming the untracked object, determine a current gaze direction of the virtual interactive avatar based on a current azimuth angle of the target object.

[00186] The third processing module 53 may be further configured to generate a dynamic display image in which the virtual interactive avatar rotates from the first gaze direction to the current gaze direction, based on the first gaze direction and the current gaze direction.

[00187] The first control module 57 may be further configured to display the dynamic display image by the display screen.

[00188] The third processing module 53 is further configured to in response to the target object failing to become the tracked object within the second duration after becoming the untracked object, update the display image to a display image in which the gaze direction of the virtual interactive avatar is a target direction.

[00189] The target direction is a second preset direction or a second gaze direction

corresponding to the azimuth angle of a next target object.

[00190] In some alternative embodiments, on the basis of any of the above embodiments, the apparatus of the embodiment of the present disclosure may further include: a seventh processing module configured to generate warning audio for the candidate object according to the azimuth angle; and a second control module configured to play the warning audio by a sound playing device on the vehicle.

[00191] The part embodiments of the present exemplary apparatus correspond to the part embodiments of above-mentioned exemplary method section in implementations, and corresponding contents between each other may be referred to, combined, or cited mutually, and details are not described herein again. Beneficial technical effects corresponding to the part embodiments of the present exemplary apparatus may refer to the corresponding beneficial technical effects in the part embodiments of above-mentioned exemplary method section, and details are not described herein again.

Exemplary Electronic Device

[00192] FIG. 15 is a diagram of a structure of an electronic device provided by an embodiment of the present disclosure, including at least one processor 91 and a memory 92.

[00193] The processor 91 may be a central processing unit (CPU) or another form of processing unit having a data processing capability and/or an instruction execution capability, and may control other components of the electronic device 90 to perform a desired function.

[00194] The memory 92 may include one or more computer program products. The computer program product may include various forms of computer readable storage media, such as a volatile memory and/or a non-volatile memory. The volatile memory may include, for example, a random access memory (RAM), a cache, and/or the like. The non-volatile memory may include, for example, a read-only memory (ROM), a hard disk, a flash memory, and/or the like. One or

more computer program instructions may be stored on the computer readable storage medium. The processor 91 may perform the one or more computer program instructions to implement the display image generation method according to each of the above-mentioned embodiments of the present disclosure and/or other desired functions.

[00195] In one example, the electronic device 90 may further include: an input means 93 and an output means 94. These components are connected to each other via a bus system and/or another form of connection mechanisms (not shown).

[00196] The input means 93 may also include, for example, a touch screen, a microphone, various sensors, and the like. The sensors may include, for example, image sensors (e.g., cameras, webcams, etc.), laser radars, millimeter wave radars, ultrasonic radars, positioning sensors, pressure sensors, air quality sensors, temperature sensors, and so forth. The image sensor, laser radar, millimeter wave radar, ultrasonic radar, etc. may be used for sensing the surrounding environment, i.e. detecting dynamic and static objects in the surrounding environment. The dynamic and static objects may include, for example, static objects such as lane lines, curbs, arrows, signboards, trees, buildings, and dynamic objects such as surrounding vehicles, pedestrians, riders, and the like. The positioning sensor is used for positioning a movable device (e.g., an ego vehicle, a robot, etc.) where the electronic device is located. The positioning sensor may include, for example, an Inertial Measurement Unit (IMU), a Global Positioning System (GPS), and the like. The pressure sensor may be used for detecting seat pressure. The temperature sensor may be used for detecting the temperature within the vehicle cabin. The air quality sensor may be used for detecting air quality within the vehicle cabin.

[00197] The output device 94 may output various types of information to the outside, which may include, for example, a display, a speaker, a communication network, a remote output device connected thereto, and/or the like.

[00198] Certainly, for simplicity, FIG. 15 shows only some of the components in the electronic

device 90 that are related to the present disclosure, and components such as a bus, an input/output interface are omitted. In addition, according to specific application situations, the electronic device 90 may further include any other appropriate components.

Exemplary Computer Program Product and Computer Readable Storage Medium

[00199] In addition to the above-mentioned method and device, the embodiments of the present disclosure may further provide a computer program product, which includes computer program instructions. When the computer program instructions are run by the processor, the processor is enabled to perform the steps, of the display image generation method according to various embodiments of the present disclosure, that are described in the above-mentioned "Exemplary Method" section.

[00200] The computer program product may be program code, written with any combination of one or more programming languages, that is configured to perform the operations of the embodiments of the present disclosure. The programming languages include an object-oriented programming language such as Java, C++, and/or the like, and further include a conventional procedural programming language such as the "C" language or a similar programming language. The program codes may be entirely or partially executed on a user computing device, executed as an independent software package, partially executed on a user computing device and partially executed on a remote computing device, or entirely executed on the remote computing device or a server.

[00201] In addition, the embodiments of the present disclosure may further provide a computer readable storage medium, which stores computer program instructions. When the computer program instructions are run by the processor, the processor is enabled to execute the steps, of the display image generation method according to various embodiments of the present disclosure, that are described in the above-mentioned "Exemplary Method" section.

[00202] The computer readable storage medium may adopt any combination of one or more readable media. The readable medium may be a readable signal medium or a readable storage medium. The readable storage medium may include, for example, but is not limited to, a system, an apparatus, or a device of electricity, magnetism, light, electromagnetism, infrared ray, or semiconductor, or any combination of the above. More specific examples (a non-exhaustive list) of the readable storage medium include: an electrical connection with one or more conducting wires, a portable disk, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or a flash memory), an optical fiber, a portable compact disk read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the above.

[00203] Basic principles of the present disclosure are described above in combination with specific embodiments. However, it should be noted that the advantages, superiorities, and effects mentioned in the present disclosure are merely examples but are not for limitation, and cannot be considered that these advantages, superiorities, and effects are necessary for each embodiment of the present disclosure must possess. In addition, specific details disclosed above are merely for examples and for ease of understanding, rather than limitations. The details described above do not limit that the present disclosure must be implemented by using the above-mentioned specific details.

[00204] A person skilled in the art may make various modifications and variations to the present disclosure without departing from the spirit and the scope of this application. In this way, if these modifications and variations fall within the scope of the claims and equivalent technologies of the claims of the present disclosure, the present disclosure also intends to include these modifications and variations.

CLAIMS:

1. A display image generation method, comprising:

in a sentry mode, in response to determining that a candidate object to be warned is present in a vicinity of a vehicle, determining an azimuth angle of the candidate object relative to a display screen based on a first position of the candidate object in a first coordinate system and a second position of the display screen in the first coordinate system;

determining a target gaze direction of a virtual interactive avatar based on the azimuth angle;
and

rendering the virtual interactive avatar based on the target gaze direction, to generate a display image in which the virtual interactive avatar gazes at a target object in the target gaze direction.

2. The method according to claim 1, wherein the first coordinate system is a two-dimensional coordinate system for a preset plane of a vehicle coordinate system; and

determining the azimuth angle of the candidate object relative to the display screen based on the first position of the candidate object in the first coordinate system and the second position of the display screen in the first coordinate system comprises:

determining a first included angle between a line segment connecting the first position and the second position and a first preset direction in the first coordinate system based on the first position and the second position, the first preset direction being a direction of a projection line of a normal of the display screen on the preset plane; and

designating the first included angle as the azimuth angle of the candidate object relative to the display screen.

3. The method according to claim 1, wherein determining the target gaze direction of the virtual interactive avatar based on the azimuth angle comprises:

determining the target object from the candidate object based on the azimuth angle and a preset angle range; and

determining the target gaze direction of the virtual interactive avatar based on an azimuth angle of the target object.

4. The method according to claim 3, wherein determining the target object from the candidate object based on the azimuth angle and the preset angle range comprises:

in response to, among the candidate objects, only one first candidate object having an azimuth angle within the preset angle range, designating the first candidate object as the target object; or

in response to, among the candidate objects, a plurality of second candidate objects having azimuth angles within the preset angle range, according to candidate durations of the plurality of second candidate objects, designating a second candidate object having the longest candidate duration as the target object, the candidate duration being a duration during which the second candidate object belongs to the candidate object to be warned.

5. The method according to claim 3, wherein determining the target gaze direction of the virtual interactive avatar based on the azimuth angle further comprises:

in response to a failure to determine the target object based on the azimuth angle and the preset angle range, determining the target gaze direction of the virtual interactive avatar to be a second preset direction.

6. The method according to claim 1, wherein rendering the virtual interactive avatar based on the target gaze direction, to generate the display image in which the virtual interactive avatar gazes at the target object in the target gaze direction comprises:

rendering to generate a dynamic display image in which a gaze light beam is emitted from the virtual interactive avatar and flickers according to a preset rule, based on the target gaze

direction and an avatar model of the virtual interactive avatar.

7. The method according to claim 1, wherein after generating the display image, the method further comprises:

in response to a change in the azimuth angle of the target object from a first azimuth angle to a second azimuth angle, determining a rotation trajectory of the virtual interactive avatar based on the first azimuth angle and the second azimuth angle; and

rendering the virtual interactive avatar based on the rotation trajectory, to generate a dynamic display image in which the gaze direction of the virtual interactive avatar changes along the rotation trajectory.

8. The method according to claim 1, wherein after generating the display image, the method further comprises:

designating the target object as a tracked object, and controlling the gaze direction of the virtual interactive avatar in the display image to rotate with changes in the azimuth angle of the target object; and

in response to a change in the target object from the tracked object to an untracked object within a first duration, maintaining the gaze direction of the virtual interactive avatar in the display image at a first gaze direction in a last frame before the target object becomes the untracked object.

9. The method according to claim 8, further comprising:

in response to the target object becoming the tracked object again within a second duration after becoming the untracked object, determining a current gaze direction of the virtual interactive avatar based on a current azimuth angle of the target object;

generating a dynamic display image in which the virtual interactive avatar rotates from the first gaze direction to the current gaze direction, based on the first gaze direction and the current

gaze direction;

displaying the dynamic display image by the display screen; or

in response to the target object failing to become the tracked object within the second duration after becoming the untracked object, updating the display image to a display image in which the gaze direction of the virtual interactive avatar is a target direction, the target direction being a second preset direction or a second gaze direction corresponding to the azimuth angle of a next target object.

10. The method according to any one of claims 1-9, further comprising:

determining a sensing result based on sensor data collected by sensors on the vehicle, the sensing result comprising state information of one or more objects;

determining the candidate object based on the sensing result; and

determining the first position of the candidate object in the first coordinate system, based on a perspective transformation matrix and a first pixel position in state information of the candidate object, the first pixel position being a pixel position corresponding to a point on the candidate object closest to the vehicle.

11. The method according to claim 10, wherein determining the candidate object based on the sensing result comprises:

determining, from one or more objects, an object of which the state information satisfies a risk trigger condition, based on the state information of the one or more objects in the sensing result and a preset risk trigger condition; and

in response to a presence of at least one object satisfying the risk trigger condition in the one or more objects, designating the object satisfying the risk trigger condition as the candidate object.

12. The method according to claim 11, further comprising:

in response to the presence of at least one object satisfying the risk trigger condition in the one or more objects, controlling the display screen to be switched from a first preset state to a first warning state;

after generating the display image, displaying the display image on the display screen; or

in response to an absence of an object satisfying the risk trigger condition in the one or more objects, controlling the display screen to maintain the first preset state.

13. The method according to any one of claims 1-9, further comprising:

generating warning audio for the candidate object according to the azimuth angle; and

playing the warning audio by a sound playing device on the vehicle.

14. A computer-readable storage medium, wherein the storage medium stores a computer program which when executed by a processor implements the display image generation method according to any one of claims 1-13.

15. An electronic device, comprising:

a memory, configured to store executable instructions by a processor; and

the processor, configured to read the executable instructions from the memory and execute the instructions to perform the display image generation method according to any one of claims 1-13.