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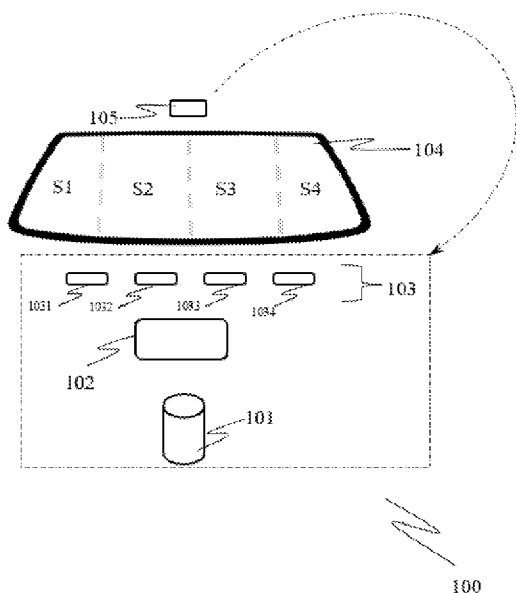


FIG. 1A

(57) **Abstract:** The present disclosure provides a dynamic heads-up display (HUD) system (100) and a method. The system comprises an acquisition unit (105) configured to obtain gaze of a driver and a projector (101) to display driver assistance information on a glazing (104). The system (100) further comprises a mirror assembly (102, 103) having plurality of mirrors, configured to position the projected display on a determined location on the glazing (104) and a control unit (110) operably configured with the acquisition unit (105) and the mirror assembly (102, 103) and configured to determine an adjustment signal and the location on the glazing for the display (106) such that the display (106) on the glazing (104) is configured to be continuously in line with the driver's gaze. The solution provides a more dynamic and responsive head-up display system that can automatically change its position of display in real-time based on the driver's gaze.

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TITLE

A DYNAMIC HEADS-UP DISPLAY IN A VEHICLE AND A METHOD OF ADJUSTING THE SAME

5

TECHNICAL FIELD

The present disclosure relates to a heads-up display in vehicles, particularly this disclosure relates to a dynamic or movable head-up display and more particularly, it
10 relates to a heads-up display which is automatically adjustable in accordance with a driver's gaze.

BACKGROUND

15 Background description includes information that may be useful in understanding the present disclosure. It is not an admission that any of the information provided herein is prior art or relevant to the presently claimed disclosure, or that any publication specifically or implicitly referenced is prior art.

20 Heads-Up Display or Head-Up Display (HUD) is a display technology that projects information directly onto the windshield or a transparent screen in a driver's line of sight, allowing them to view data without looking down at the dashboard or other devices. In the initial days it has been developed for aircraft but nowadays, it finds wide application in the automotive industry for providing drivers with vital information,
25 such as speed, navigation directions, fuel levels, and more. HUD is essentially useful in scenarios where the driver needs to be provided with useful information in a non-distracting and convenient manner while driving. Windshield-projected HUD, combiner-projected HUD and smart device-based HUD are some instances of the conventionally used HUD. HUD is a futuristic means for providing enhanced safety,

improved navigation and convenience that finds various application in the field of Advanced driver-assistance systems (ADAS).

Reference is made to *KR2016-0123784* that discloses a display device for a vehicle comprising a processor which determines the position of a driver seat in a vehicle and a display part which displays an image for the input of a selection command and displays the image in a display position determined according to the position of the driver seat. This display has an easily operated user interface. Such displays may not always be in alignment with the driver's gaze. The driver's field of vision changes as he/she drives. This follows that in case the driver changes his/her gaze, the useful data displayed on the HUD is out of the driver's view. This is primarily because of the HUD is static with respect to the changing field of vision of the driver.

Again, another reference is made to *US11407359B2* that discloses a solution for displaying the content on a glass window of a vehicle. Such displaying includes capturing sight information of surrounding scenery of the vehicle during a first time period, by using at least one first image capturing device, identifying a request for displaying content related to the sight information from a user during a second time period after the first time period, and displaying the content related to the sight information on the glass window of the vehicle based on the request. This display solution allows the user to choose how and what are the kind of information that need to be displayed. Even though this solution allows different modes of view of the HUD, it does not disclose or suggest a driver's gaze-based display.

Yet another reference is made to *US11294265B2* that discloses a display device of an autonomous vehicle which is controlled based on data collected from sensors located in or on the vehicle. Said display device is used to present one or more images to a driver and/or passengers of the autonomous vehicle. The display device may be, for example, a windshield and/or another window of the vehicle. However, even said

solution lacks any provision for changing the position of the display based on the driver's field of vision or gaze.

5 In conventionally known HUD, the location of the display is static, and it does not re-project based on where the driver is looking at or his/her line of sight. In view of the prior art solutions known, either there are no solutions about dynamically moving the HUD depending on the driver's gaze or it has been observed that HUD systems are not fast enough to project the image for display in real time to the driver's field of vision. This consequently results in mismatch of alignment between a driver's gaze and
10 display, thereby exposing to safety risks. The driver's convenience-based customization of the location for HUD of prior art solutions lacks the flexibility to dynamically and on real basis adjustment of the HUD image projection depending on driver's gaze.

15 In view of the prior art known hitherto, it has been observed that there exists a requirement of a more dynamic and responsive head-up display system that can automatically change its position of display in real-time based on the driver's gaze.

SUMMARY OF THE DISCLOSURE

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An object of the present invention is to provide a dynamic heads-up display system in a vehicle.

Another object of the present invention is to provide a heads-up display system in a
25 vehicle that changes its display projection in alignment with the driver's field of view.

Yet another object of the present invention is to provide a heads-up display system that reduces the safety issues by ensuring critical information being displayed to the driver.

Still another object of the present invention is to provide to a solution to always project the image in real time to the driver's field of vision when HUD is enabled.

5 A further object of the present invention is to provide a heads-up display system capable of projecting the display in any desirable segment of a vehicle's glazing according to a driver's convenience.

These and other objects of the invention are achieved by the following aspects of the invention. The following disclosure presents a simplified summary of the invention in
10 order to provide a basic understanding of some aspects of the invention. This presents some concept of the invention in a simplified form to a more detailed description of the invention presented later. It is a comprehensive summary of the disclosure, and it is not an extensive overview of the present invention. The intend of this summary is to provide a fundamental understanding of some of the aspects of the present invention.

15

In an aspect of the present invention is provided a dynamic heads-up display system in a vehicle. Said system comprises an acquisition unit configured to obtain gaze of a driver in the vehicle, a projector with a light source configured to display driver assistance information on a glazing of the vehicle, a mirror assembly having plurality
20 of mirrors, configured to position the projected display on a determined location on the glazing and a control unit operably configured with the acquisition unit and the mirror assembly. Said control unit is configured to determine the location on the glazing for the display and the display on glazing is configured to simultaneously change in line with a change in the driver's gaze. The control unit is configured to determine separate
25 adjustment signals. The projector, and the mirror assembly are configured to reposition the display based said adjustment signal from the control unit. The glazing comprises one or more predetermined segments for display. The mirror assembly comprises plurality of titling mirrors arranged in reference to a position of the projector and the number and position of the mirrors of the mirror assembly are chosen based on one or

more predetermined segments for display provided on the glazing. Said projector and said mirrors are configured to rotate and project the display on the determined location based on the adjustment signal from the control unit.

- 5 In this aspect, the mirror assembly comprises a primary movable mirror and one or more secondary mirrors wherein said secondary mirrors are aligned with the predetermined segments for display on the glazing. The control unit is configured to determine an angle of projection combined reflection depending on the shape and placement of the mirror assembly, positioning of the glazing and lighting conditions.
- 10 The primary movable mirror is configured to adjust the angle of rotation in a range of acute angles to obtain reflections for projecting a heads-up display image. The acquisition unit is configured to obtain a facial orientation and iris position for obtaining the driver's gaze. The projector and the plurality of mirrors are coupled with a step motor for rotation, wherein said step motor receives signals from the control unit
- 15 for rotation. The control unit is configured to generate the adjustment signal after a minimum wait period post detection of a change in the driver's gaze. The acquisition unit and control unit are operably configured to continuously monitor driver's gaze. The control unit is operably coupled with the vehicle electronic control unit for obtaining inputs and signals for display. The control unit is configured to send separate
- 20 adjust signals to the projector and the plurality of mirrors of the mirror assembly. The change in driver's gaze is determined in reference orientation for eye co-ordinates is with respect to a mid-point of the glazing. The plurality of mirrors includes mechanical shields for preventing internal reflections. Each region of said predetermined segments is defined using curvature data of the glazing, and said curvature being pre-fed in the
- 25 control unit.

In another aspect of the present invention is provided a method of dynamically adjusting the heads-up display system as disclosed in the earlier aspect. This method comprises continuously monitoring, by the acquisition unit, the driver's gaze to detect

- a change in the driver's gaze, and deriving, by the control unit, a set of co-ordinates for display on the glazing. It further includes checking, by the control unit, whether the change in the driver's gaze is persistent for a period of minimum wait period. Further to which, the method includes determining, by the control unit, one or more adjustment
- 5 signals for rotating the projector and/or the plurality of mirrors such that the final display on the glazing is in alignment with the driver's gaze. It finally includes adjusting the projector and/or plurality of mirrors, to reflect the display on the glazing in alignment with the driver's gaze. The adjusting of the projector and/or plurality of mirrors further comprises titling, a primary mirror to adjust the reflection of display
- 10 image from the projector, identifying one or more secondary images for further reflection of the display and projecting the final display in alignment with the driver's gaze. The method further comprises obtaining inputs from plurality from vehicle electronic control unit for displaying on the glazing.
- 15 In yet another aspect of the present invention is provided a mechanical mounting assembly for holding the one or more mirrors of the plurality of mirrors of the dynamic heads-up display system. Said mechanical mounting assembly comprises one or more corner locator holders configured to hold a mirror. The assembly has plurality of actuators configured to provide linear movement to the corners of said mirror, said
- 20 actuators being mechanically coupled with the each of said one or more corner locator holders. It further has a stepper motor mechanically coupled with each said actuators, configured to provide incremental linear control to the movement of said actuators. The mounting assembly further has a joint mechanically coupled with each of said actuators configured to convert a linear motion of said actuators to facilitate a desired motion.
- 25 Each of these joint exhibits 12 degrees of freedom. Each of said actuators, joint and corner locator holders are mechanically coupled to provide a coordinated dynamic motion of the mirror to redirect a heads-up display image on the glazing. Each of corner locator holders are configured to rotate with a rotation of the respective joint and axis of rotation of corner holder is in line with the axis of rotation of the respective stepper

motor. The corners of said mirror are configured to move said mirror linearly with respect to a motion of the actuators and the direction of alignment of the mirror is in line with a region of projection in the glazing with a center point of the mirror always remaining constant. Said desired motion is dependent on signal obtained from the control unit.

The head up display device with a projection section is configured to emit projected light. Said projection section includes a light source to emit light rays, an image generating section configured to convert light rays from the light source into image light rays, a tilting mirror section to project the image light rays to a segment of the glazing (like a windshield) in accordance with the gaze of the driver. The disclosed solution provides head-up display (HUD) system that improves the driving experience for users by changing the formation of HUD images on the segmented areas of the windshield depending upon tracking of the driver's eye position, angle of projection combined reflection, and deployment of the mirror assembly. The dynamic changing of the HUD image is such that it is in line with the driver's gaze and accordingly, it never fails to miss any critical information from being projected.

The significant features of the present invention and the advantages of the same will be apparent to a person skilled in the art from the detailed description that follows in conjunction with the annexed drawings.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

The following briefly describes the accompanying drawings, illustrating the technical solution of the embodiments of the present invention or the prior art, for assisting the understanding of a person skilled in the art to comprehend the invention. It would be apparent that the accompanying drawings in the following description merely show some embodiments of the present invention, and persons skilled in the art can derive

other drawings from the accompanying drawings without deviating from the scope of the disclosure.

FIG 1A illustrates a schematic diagram showing the heads-up display system according to an embodiment of the present invention.

FIG 1B illustrates a schematic diagram showing the reflections by the mirror assembly for the dynamic change of the HUD according to an embodiment of the present invention.

FIG 2 illustrates a diagram showing the divisions in the glazing according to an embodiment of the present invention.

FIG 3A-3B illustrate diagrams showing the mirror assembly and the movement exhibited by the mirrors for the dynamic change of the HUD according to an embodiment of the present invention.

FIG 4 illustrates a detailed diagram showing the reflections by the mirror assembly for the dynamic change of the HUD according to an embodiment of the present invention.

FIG 5A illustrates a block diagram showing the heads-up display system according to an embodiment of the present invention.

FIG 5B illustrates a control flow diagram showing method of control of the heads-up display system according to an embodiment of the present invention.

FIG 6A illustrates a mechanical assembly for a mirror according to an embodiment of the present invention.

FIG 6B illustrates an instance of a joint for a mechanical assembly for a mirror according to an embodiment of the present invention.

Persons skilled in the art will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale. For example, the dimensions of some of the elements in the figures may be exaggerated relative to other elements to help to improve understanding of embodiments of the disclosure.

DETAILED DESCRIPTION

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The present disclosure is now discussed in more detail referring to the drawings that accompany the present application. It would be appreciated by a skilled person that this description to assist the understanding of the invention, but these are to be regarded as merely exemplary.

15

The terms and words used in the following description are not limited to the bibliographical meanings and the same are used to enable a clear and consistent understanding of the invention. Accordingly, the terms/phrases are to be read in the context of the disclosure and not in isolation. Additionally, descriptions of well-known functions and constructions are omitted for clarity and conciseness.

20

In an embodiment of the present invention is provided a dynamic heads-up display system (100) in a vehicle (112) as depicted in FIG. 1A. Said heads-up display system (100) comprises a projector (101) with a light source configured to display driver assistance information on a glazing (104) of the vehicle (112). The system further includes an acquisition unit (105) configured to obtain information about the gaze of a driver in the vehicle (112). Said system is further configured to project the HUD image based on the driver's gaze. This system (100) further comprises a mirror assembly (102, 103) having plurality of mirrors, configured to position the projected display on a

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- determined location on the glazing (104). The system (100) includes a control unit (110) operably configured with the acquisition unit (105), the projector (101), and the mirror assembly (102, 103). Said control unit (101) is configured to determine an adjustment signal and the location on the glazing for the display (106). The projector (101) and the mirror assembly (102, 103) are configured to reposition the display based on the received adjustment signal from the control unit (110) such that the display (106) on the glazing (104) is configured to be continuously in line with the driver's gaze. In an instance say, while driving if the driver is gazing at a moving object on the road through the glazing, the image displayed by the HUD is configured to position and/or reposition its location of display on the glazing such that the display image is always in the field of view of the driver. The positioning and/or repositioning is on real-time basis with respect to change in gaze of the driver. This implies that irrespective of where the drive is looking at, the HUD image will be constantly displayed for him.
- 15 In an embodiment of the present invention, the glazing (104) may be divided into different segments (S1, S2, S3, S4) for display. The number and position of the mirrors of the assembly (102, 103) are chosen based on one or more of the predetermined segments (S1, S2, S3, S4) for display (106). Said mirror assembly (102, 103) comprises a primary movable mirror (102) and one or more secondary mirrors (1031, 1032, 1033, 1034). In said embodiment, secondary mirrors (103) may be a tilting mirror section. Said mirrors (102, 1031, 1032, 1033, 1034) are configured to be arranged in alignment with the predetermined segments (S1, S2, S3, S4) for display on the glazing (104) arranged and in reference to a position of the projector.
- 25 Reference is made to FIG. 1B that depicts a scenario of displaying the HUD image on different segments of the glazing. Depending upon the gaze of the driver, the orientation of the primary mirror (102) and the secondary mirrors (1031, 1032, 1033, 1034) are determined by the control unit (110). The primary and secondary mirrors (102, 103) may be arranged on the dashboard only or alternatively may be arranged at

the top region vehicle along with the dashboard. In an exemplary implementation, the mirror assembly (102, 103) involves using four mirrors (1031, 1032, 1033, 1034) on the top of the dashboard and four mirrors on the bottom of the dashboard, along with the primary mirror (102) and the projector (101). The primary mirror (102) would reflect the image by the projector (101) onto the plurality of mirrors on the top and the bottom of the dashboard. This in turn would then reflect the image onto the windshield in the driver's line of sight. By adjusting the angles of tilt or movement of the mirrors, the image may be projected onto different areas of the glazing (such as and not limited to windshield) for the display to be in line with the driver's line of sight. In another exemplary implementation as seen from FIG. 1B, based on gaze, if image need to be displayed at segment S2, primary mirror (102) and secondary mirror (1032) are chosen. The image from projector (101) gets reflected first on the primary mirror (102) and followed by the reflection on the secondary mirror (1032). In said FIG, it is seen as AB getting reflected as BE and then finally as EF at segment S2.

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In an embodiment of the present invention, the control unit (110) is further configured to determine an angle of projection combined reflection depending on a number of parameters. In a preferred embodiment, control unit (110) is configured to determine said angle of projection combined reflection depending on a shape and placement of the mirror assembly (102, 103), positioning of the glazing (104) and lighting conditions. The primary movable mirror (102) is configured to adjust the angle of rotation in a range of acute angles to obtain reflections for projecting a heads-up display image as depicts in FIG. 3B. In an exemplary implementation of the present invention, the HUD system (100) may include the projector (101) having a primary mirror as a bottom reflector (M1), a secondary mirror as a middle reflector (M2) and another secondary mirror as a top reflector (M3) as seen in FIG. 3A. The angle of the bottom reflector (M1) is tilted by an angle θ , such that θ may go up to 5 degrees to achieve the desired reflections on the middle reflector (M2) and top reflector (M3). The projector (101), middle reflector (M2) and top reflector (M3) are maintained at a constant angle.

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The reflections, image accuracy and resolution of the projections may be defined depending on the angle of the curvature of the glazing and the external light conditions.

Reference is made to FIG. 3 that depicts a division of the glazing (314) as per a preferred embodiment of the present invention. This will facilitate the precise projection of the image (313) on the glazing. The glazing (314) may be divided into multiple points on its surface, referenced from an origin as x,y,z points (for instance). The control unit may then evaluate the best point of projection with respect to the viewpoint of driver. The rotation of the mirror (312) may be calculated to align the projection to a point on the glazing. The final position of the mirror may be the calculated movement of the mirror for the new place of image. In an implementation, each region of said predetermined segments (S1, S2, S3, S4) is defined using curvature data of the glazing, and said curvature being pre-fed in the control unit (110).

Reference is made to FIG. 4 that depicts the schematic diagram showing the architecture of the HUD system according to an embodiment of the present invention. It comprises the acquisition unit (105) facing driver's eyes and operably coupled with the control unit (110). Said acquisition unit (105) may be and not limited to a camera such as an IR camera, which communicates image data to the control unit (110). The control unit (110) is connected to the projector (110) and one or more mirror assembly (102, 1031, 1032) that project the image onto the glazing (104). The control unit (110) is configured to send separate adjustment signals to the projector (101) and the plurality of mirrors (102, 103) of the mirror assembly. In an implementation, the change in driver's gaze is determined in reference orientation for eye co-ordinates is with respect to a mid-point of the glazing. Upon observing the change in driver's gaze with respect to a pre-determined position on the glazing (104), the control unit (110) is configured to separately calculate the rotation position required for fast moving of the mirrors (102, 1031, 1032) and relatively slow-moving projector (101). In an implementation, both these rotations may be achieved by two separate stepper motors. The control unit (110)

is configured to verify the total rotations are aligned with the driver's gaze on the glazing (104). In an implementation, the acquisition unit (105) and control unit (110) are operably configured to continuously monitor driver's gaze. The acquisition unit (105) is adapted to capture the driver's eye orientation (130). The control unit (110) is configured to further convert this information into an adjustment signal or instruction that is executed by one or more tilting mirrors, which projects the image onto the exact segment of the glazing where the driver is orienting. In an embodiment, the control unit (101) is configured to ensure that the motion of one or more mirrors and the projector is synchronized to respond to the driver's gaze in a stipulated duration. The control unit (101) is configured to include a simultaneous or programmed time delay-based movement of the mirrors as way to achieve the response time for the driver's gaze. The movement of the primary (101), secondary mirrors (103) and projector (101) are such that it compensates for the relative motion between the vehicle and a target object. In an implementation, the mirror assembly may be encapsulated or encased in a single unit or may be suitably disposed in the vehicle. The plurality of mirrors may include mechanical shields for preventing internal reflections.

In an exemplary implementation of the present invention, the control unit (110) may be configured to adjust a first mirror to control the size and location of the image produced by the projector (110), which would then be reflected onto the secondary mirrors (1031, 1032, 1033, 1034) and ultimately projected onto the glazing (104). Further, the control unit (110) is configured to adjust the secondary mirrors (1031, 1032, 1033, 1034) to ensure that the virtual image produced by the projector (110) is reflected onto the appropriate segment of the glazing (104) in accordance with the driver's orientation and gaze. The control unit (110) is configured to adjust the projector (110) to modify the intensity and focus of the projected image, which would affect its visibility and clarity on the glazing (104). In an exemplary embodiment, the configuration could involve using four mirrors on the top of the dashboard and four mirrors on the bottom of the dashboard, along with a primary mirror (102) and a

projector (101). The primary mirror (102) would reflect the image projected by the projector (101) onto the four mirrors on the top and the bottom of the dashboard, which in turn are adapted to then reflect the image onto the windshield in the driver's line of sight. By adjusting the angles of the mirrors, the image may be projected onto different areas of the windshield to accommodate the driver's line of sight. The control unit (110) is advantageously configured for precise and coordinated adjustments between the primary mirror, secondary mirrors, and projector to ensure an accurate and effective HUD display for the driver. The control unit (101) of the present invention is thus fast enough in projecting the image in real time to the driver's field of vision.

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The one or more embodiments of the present invention is configured to project the image in real-time to the driver's field of vision. This is facilitated by projecting the HUD image based on the driver's gaze. The system is configured to adjust mirrors of the mirror assembly in real-time basis, depending on gaze of the driver and in turn project the contents for the HUD on one of the segments of a glazing. The system is configured to ensure the critical information is always projected to the driver on the HUD. It has been observed that the conventional heads-up display systems are not fast enough in projecting the image in real time aligning with the driver's field of vision. With the introduction of plurality of mirrors and the movement thereof in the HUD system, it is ensured that there is no mismatch of alignment between a driver's gaze and the display of critical information on the HUD.

Reference is made to FIG. 5A of the present disclosure that shows a block diagram of the system as per the present invention. The HUD control unit (110) may be operably coupled with the vehicle ECU (140) and which in turn may be configured with one or more means (150) configured to provide input for display. The acquisition unit (105) may be configured with the HUD control unit (110). The projector (101) and the mirror assembly (102, 103) are also configured with HUD control unit (110) for display of the HUD image (106) at a selected location of the glazing (104). In an exemplary

implementation, the vehicle ECU (140) is configured to be coupled with one or more input sources such as blind spot detection sensors, ultrasonic sensors, obstacle detection units and the like. Said input data may include critical information for assisting the driver such as and not limited to blind spot, navigation information, speed, and the like.

5 In an implementation, said input may be obtained from one or more sources within the vehicle or through a network connected via the internet. The system may further include one or more sensors for identifying the category of icons to be displayed on the HUD image for a particular instance. The choice of the icon display may be made by the user. In an implementation, vehicle ECU (140) may be connected to a cloud
10 network thereby configured for sharing suitable data for display on the glazing (104). In an implementation of the invention, the HUD control unit (110) may be operably configured with the vehicle ECU (140). The HUD control unit (110) may be configured to the mirror assembly (102, 103), projector (101) via CAN means enabling the rotation of the mirror assembly (102, 103) and projector (101) respectively. The acquisition unit
15 (105) is configured for acquiring the driver eyes orientation. The control unit (110) is on the other hand, configured to receive the information acquired by acquisition unit (105), process the information and convert the information into an adjustment signal. Based on said adjustment signal, the control unit (110) is capable to adjust the tilting of the mirror simultaneously with the driver orientation, to enable formation of image
20 onto that discrete segment of the glazing.

The control unit (110) is configured to enable the simultaneous adjusting of the tilted mirror assembly (102, 103) to display projected image on the glazing segment in line with the gaze of the driver. In a preferred embodiment, there may be secondary mirrors
25 (103) may be two or more to cover the entire glazing or a particular segment of interest of the glazing depending on driver's orientation. The connectivity between the acquisition unit or the sensing camera (105) and the projector (101), and the projector (101) with the mirror assembly (102, 103), with other hardware parts coordinates in accordance with the gaze of the driver for an aligned heads-up display system. The

heads-up system wherein the adjusting mirror assembly is configured to changing the position so that the image on the mirror coincides with that discrete segment of the glazing where the driver is orienting towards. In an embodiment of the present invention is provided an eye-tracking system having the acquisition unit (105) that is
5 capable of accurately tracking the driver's eye orientation in real-time and adjust the HUD display (106) accordingly. Displaying critical information on the windshield glass assists in various applications associated with Advanced Driver Assistance Systems (ADAS).

10 In an implementation of the present invention the acquisition unit (105) operably connected with the control unit (110) is configured to continuously monitor or track the driver's eye position with the acquisition unit (105) like an image capturing device (such as a camera) facing the driver. The image capturing device (105) continuously sends images to the control unit (110), it then stores them in its memory. The control
15 unit (110) is configured to identify any significant change on comparing with a pre-determined value (stored in the memory) in eye orientation. The reference orientation for eye co-ordinates is with respect to mid-point of the glazing (104). If the control unit (110) determines a change in eye-orientation, it further calculates the necessary co-ordinates to move the HUD image from its current placement on the glazing (104).

20

The control unit (110) is configured to generate the adjustment signal after a minimum wait period post detection of a change in the driver's gaze. The control unit (110) initiates the change in placement of the image formed on to the glazing (104). The control unit (110) is configured to derive the necessary but specific movements
25 required for each module of the mirror assembly (102, 103) or projector (101) associated with HUD, considering the maximum speed of movement possible for each of said modules. The control unit (110) is further configured to provide separate adjustment signals such as separate movement instructions to rotate tilting mirror assembly (one or more movable mirrors) in HUD. Finally, the total movement of all

modules or individual devices together ensures alignment with the driver's eye position on the glazing (104).

Thus, as per the present invention, based on facial orientation and iris position of the driver, the control unit (110) is configured to determine the orientation of the primary
5 movable mirror (102) and selection of a secondary mirrors (103). This in turn consequently projects the content on one of the segments (S1, S2, S3, S4) of the glazing (104) which is aligned with driver's eyesight. In an implementation, the control unit (110) is configured to obtain the driver's iris position as detected by the acquisition
10 unit (105) and based on which the mirror tilt may be adjusted so that the HUD is aligned with driver's gaze. The control unit (110) is configured to wait for a pre-determined time (referred as 'hysteresis') and thereby adapted to check if eye iris stays beyond this hysteresis time to determine the mirror tilting requirements. For the purpose, determination of the angle of projection is based on the angle of projection combined
15 reflection depending on the shape and placement of the mirror assembly (102, 103) and other glazing parameters. The mirrors of the mirror assembly (102, 103) may be such that it is adapted to the dimensions and curvature of the glazing to achieve the output projections with the desired resolution and image quality. The control unit (110) is then further configured to convert this data into an adjustment instruction that is executed
20 by the tilting mirror assembly, which projects the HUD image for display onto the exact segment of the glazing where the driver's gaze is orienting.

In an embodiment of the present invention, the acquisition unit and control unit are operably configured to continuously monitor driver's gaze. The control unit (110) is
25 configured to send separate adjustment signals to the projector (101) and the plurality of mirrors (102, 103) of the mirror assembly. The control unit (110) is configured to generate the adjustment signal after a minimum wait period post detection of a change in the driver's gaze. The change in driver's gaze is determined in reference orientation for eye co-ordinates is with respect to a mid-point of the glazing. The control unit (110)

as per this embodiment is further configured to incorporate the simultaneous or programmed time delay-based movement of the mirrors as way to achieve the response time for the gaze.

5 In an embodiment of the present invention is provided a method of dynamically adjusting the heads-up display as seen in FIG. 5B. Said method comprises the acquisition unit to continuously monitoring (S101) the driver's gaze to detect a change in the driver's gaze. Further to this, it includes the control unit being configured to derive (S102) a set of co-ordinates for display on the glazing. The method further
10 includes checking (S103), by the control unit, whether the change in the driver's gaze is persistent for a period of minimum wait period and determining (S104), by the control unit, one or more adjustment signals for rotating the projector and/or the plurality of mirrors such that the final display on the glazing is in alignment with the driver's gaze.

15

The control unit is configured to determine the adjustment signals based on the requirement of the motion of the mirrors and/or projector for the HUD image to be in line with the driver's gaze. Determining the adjustment signal by the control unit includes simultaneous or programmed time delay-based movement of the mirrors being
20 used to achieve the response time for the gaze. It further includes determining adjustment signals for being able to compensate for the relative motion between the vehicle and the target object. The method further includes finally adjusting (S105) the projector and/or plurality of mirrors, to reflect the display on the glazing in alignment with the driver's gaze. The adjustment of the mirrors or projector may be performed
25 via stepper motors. In an implementation, adjusting (S105) the projector and/or plurality of mirrors further comprises titling (S201), a primary mirror to adjust the reflection of display image from the projector, identifying (S202), one or more secondary images for further reflection of the display and further projecting (S203) the

final display in alignment with the driver's gaze. The method also includes obtaining inputs from plurality from vehicle electronic control unit for displaying on the glazing.

Reference is made to a mechanical mounting assembly (600) for holding the one or
5 more mirrors of the plurality of mirrors of the dynamic heads-up display system (100)
as depicted FIG. 6A. The mechanical mounting assembly (600) comprises one or more
corner locator holders (604) configured to hold a mirror (605) and plurality of actuators
(602) configured to provide linear movement to the corners of said mirror (605), said
actuators (602) being mechanically coupled with the each of said one or more corner
10 locator holders (605). Said actuators may be screw rods. The assembly further
comprises a stepper motor (601) mechanically coupled with each said actuators (602),
configured to provide incremental linear control to the movement of said actuators
(602). It has a joint (603) mechanically coupled with each of said actuators (602)
configured to convert a linear motion of said actuators (602) to facilitate a desired
15 motion. Said joint (603) exhibits 12 degrees of freedom. Each of said actuators (602),
joint (603) and corner locator holders (604) are mechanically coupled to provide a
coordinated dynamic motion of the mirror (605) to redirect a heads-up display image
on the glazing. Said joints may be a linearly translatable joint, a sliding joint, a hooke
joint, a ball joint. FIG. 6B provides an implementation with ball joint, while FIG. 6A
20 depicts it as hooke joint. The movement of the joints include programmed rotatory or
angular motion or linear or slide motion. This motion is dependent on the instructions
from control unit. Each of corner locator holders (604) are configured to rotate with a
rotation of the respective joint (603) and axis of rotation of corner holder (604) is in
line with the axis of rotation of the respective stepper motor (601). The corners of said
25 mirror (605) are configured to move said mirror (605) linearly with respect to a motion
of the actuators (602) and the direction of alignment of the mirror (605) is in line with
a region of projection in the glazing with a center point of the mirror (605) always
remaining constant. Said desired motion is dependent on signal obtained from the
control unit (110).

In an implementation of the present invention is provided the control unit being configured to adjust a first mirror to control the size and location of the image produced by the projector. In an implementation, this would then be reflected onto one or more
5 secondary mirrors and finally projected onto the glazing. The control unit is configured to adjust the secondary mirrors to ensure that the virtual image produced by the projector is reflected onto the appropriate segment of the glazing in accordance with the driver's orientation and gaze. In an implementation of the present invention, the control unit is configured to generate the adjustment signal based on the time response
10 of the overall system. The time response of the system is optimized in such a way that the motion of the one or more mirrors are synchronized to respond to the driver's gaze in a stipulated duration. The control unit is configured to gauge the persistence in change in gaze of the driver and consequently send one or more adjustment signals to the plurality of mirrors.

15

In an exemplary embodiment of the present invention is provided a method for dynamically adjusting the heads-up display. The acquisition module is constantly tracking the driver eye alignment to detect the gaze of the driver. The control unit is configured to check if the time of the change in gaze of the driver is more than a set
20 waiting period. Said waiting period may be referred to as the predetermined hysteresis delay. The control unit is configured to receive the adjustment signal, obtained based on the angle required for the motion (such as a tilting motion) of the one or more identified mirrors. The control unit is configured to determine separate adjustment signals for the primary mirror, the secondary mirror and the projector. The vehicle ECU
25 may be connected to the control unit for obtaining inputs for display or projection on the glazing. Said input devices may include blind spot detection camera, ultrasonic sensor, and the like.

In an embodiment of the present invention, the position of the primary mirror (102) is in line with the projector (101) and one or more secondary mirrors (1031, 1032, 1033, 1034) are positioned in line with any one of the segments of the glazing (104). The control unit (101) is configured to bring forth parallel tilt of the projector (101), primary and secondary mirrors (102, 103). The HUD images may include images capable of exhibiting animations (spatial coordinates movement with respect to time) or the projected images are capable of moving on the glazing. It may be provided as function of tilt angles and speed. The parallel tilt reduces the overall response time, and thereby making the display possible within the gazing time in any given location on the glazing.

This configuration permits comfortable display of HUD in line with driver's eye iris movement. The one or more embodiments of the present invention, improves driver safety and convenience, particularly in low-light conditions. This provides improved safety, increased comfort, enhanced visibility, personalized display, and dynamic adjustments that improve accuracy and responsiveness. The solution permits for the projection of the image in the exact segment of the glazing (such as windshield), where the driver is orienting towards. This may provide a more personalized driving experience and enhance driver convenience. This consequently improves overall situational awareness and make driving safer and more convenient.

The present invention advantageously provides a seamless and undistorted image projection within the driver's field of vision while maintaining consistent image quality throughout the segments of display of glazing. The present invention significantly reduces costs associated with additional equipment and installation. It incorporates the use of fast-moving mirrors, besides a projector. Upon observing the change in driver's gaze with respect to a pre-determined position on the windshield, the HUD control unit calculates the rotation position required for fast moving mirrors and relatively slow-moving projector separately. Both these rotations are achieved by two separate stepper motors. The control unit then verifies the total rotation is equal to the driver gaze on to the windshield. The speed of the stepper motor controlling the relatively light weight

tilting mirror is faster than the speed of the stepper motor that is controlling the projector. This difference brings the advantage of using the tilting mirrors, thereby providing improved HUD system.

5 Some advantages of the present invention are enlisted in the following:

- Constant access to critical driver assistance information: With this vision aligned HUD system as per the present invention, the drivers can access important data such as speed, navigation, and fuel levels quickly and constantly without having to take their eyes off the road. The solution may be particularly
10 beneficial in situations where split-second decisions are required, such as avoiding an obstacle on the road. Since the disclosed system is capable of adjusting the projecting assembly in accordance with the driver's orientation to project information directly onto the glazing, drivers do not have to shift their focus between the road and the dashboard, thereby reducing eye strain.
- Improved user experience: This solution involves real-time dynamic adjustments of the tilting mirror assembly based on the driver's orientation. Therefore, it provides a more accurate and responsive display, thereby improving overall driving experience and safety. Additionally, since the display
15 is on the front window or windshield, the driver need not keep his/eye at the dashboard for critical information or infotainment screen frequently. This prevents the causing of eye fatigue over time, presents enhanced driving experience.
- Improved road awareness: With the disclosed solution, the drivers are capable of maintaining their focus on the road and at the same time have access to
20 critical information, such as speed, direction, and traffic information. This consequently improves overall road awareness and helps drivers stay alert while driving. Additionally, this system allows the drivers more flexibility
25

providing personalized data for display. It can be customized to display on the aligned vision of the driver.

Features that are described and/or illustrated with respect to one embodiment may be
 5 used in the same way or in a similar way in one or more other embodiments and/or in combination with or instead of the features of the other embodiments.

List of reference numerals appearing in the accompanying drawings and the corresponding features:

- 10 100: Head Up Display System
 - 101: projector
 - 102: primary mirror, 103: plurality of secondary mirrors
 - 1031, 1032, 1033, 1034: secondary mirrors
 - 104, 314: glazing
- 15 S1, S2, S3, S4...: segments in glazing
 - 105: camera
 - 106: HUD displayed image
 - 110: HUD Control Unit
 - 112: vehicle body
- 20 130: driver's gaze
 - M1: Bottom mirror
 - M2: Middle mirror
 - M3: Top mirror
 - 140: Vehicle ECU
- 25 S101-S106: Steps of the method
 - 312, 605: mirror
 - 313: projection of the image
 - 600: mounting assembly
 - 601: stepper motor

602: plurality of actuators

603: a joint

604: corner locator holders

CLAIMS

1. A dynamic heads-up display system (100) in a vehicle (112), comprising:
an acquisition unit (105) configured to obtain gaze of a driver in the vehicle
5 (112);
a projector (101) with a light source configured to display driver assistance
information on a glazing (104) of the vehicle (112);
wherein said system (100) further comprises
a mirror assembly (102, 103) having plurality of mirrors, configured to position
10 the projected display on a determined location on the glazing (104); and
a control unit (110) operably configured with the acquisition unit (105) and the
mirror assembly (102, 103) and configured to determine an adjustment signal and the
location on the glazing for the display (106); and
the projector (101) and the mirror assembly (102, 103) are configured to
15 reposition the display based on the received adjustment signal from the control unit
(110) such that the display (106) on the glazing (104) is configured to be continuously
in line with the driver's gaze.
2. The dynamic heads-up display system (100) as claimed in claim 1, wherein the
20 number and position of the mirrors of the mirror assembly (102, 103) are chosen based
on one or more predetermined segments (S1, S2, S3, S4) for display (106) provided on
the glazing (104).
3. The dynamic heads-up display system (100) as claimed in claim 1 or claim 2,
25 wherein said mirror assembly (102, 103) comprises a primary movable mirror (102)
and one or more secondary mirrors (1031, 1032, 1033, 1034) configured to be arranged
in alignment with the predetermined segments (S1, S2, S3, S4) for display on the
glazing (104) arranged and in reference to a position of the projector (101).

4. The dynamic heads-up display system (100) as claimed in any one of claims 1-3, wherein the control unit (110) is further configured to determine an angle of projection combined reflection depending on the shape and placement of the mirror assembly, positioning of the glazing and lighting conditions.

5

5. The dynamic heads-up display system (100) as claimed in any one of claims 1-4, wherein the primary movable mirror (102) is configured to adjust the angle of rotation in a range of acute angles to obtain reflections for projecting a heads-up display image.

10

6. The dynamic heads-up display system (100) as claimed in any one of claims 1-5, wherein the acquisition unit (105) and control unit (110) are operably configured to continuously monitor driver's gaze.

15 7. The dynamic heads-up display system (100) as claimed in any one of claims 1-6, wherein the control unit (110) is configured to send separate adjustment signals to the projector (101) and the plurality of mirrors (102, 103) of the mirror assembly.

8. The dynamic heads-up display system (100) as claimed in any one of claims 1-20 7, wherein the control unit (110) is configured to generate the adjustment signal after a minimum wait period post detection of a change in the driver's gaze.

9. The dynamic heads-up display system as claimed in any one of claims 1-8, wherein the change in driver's gaze is determined in reference orientation for eye co-ordinates is with respect to a mid-point of the glazing (104).
25

10. The dynamic heads-up display system as claimed in any one of claims 1-9, wherein each region of said predetermined segments (S1, S2, S3, S4) is defined using curvature data of the glazing, and said curvature being pre-fed in the control unit (110).

5 11. A method of dynamically adjusting the heads-up display as claimed in any one of the preceding claims 1-10, wherein said method comprises:

continuously monitoring (S101), by the acquisition unit, the driver's gaze to detect a change in the gaze;

10 deriving (S102), by the control unit, a set of co-ordinates for display on the glazing;

checking (S103), by the control unit, whether the change in the driver's gaze is persistent for a period of minimum wait period;

15 determining (S104), by the control unit, one or more adjustment signals for rotating the projector and/or the plurality of mirrors such that the final display on the glazing is in alignment with the driver's gaze; and

adjusting (S105) the projector and/or plurality of mirrors, to reflect the display on the glazing in alignment with the driver's gaze.

20 12. The method of dynamically adjusting the heads-up display as claimed in claim 11, wherein adjusting (S105) the projector and/or plurality of mirrors further comprises:

titling (S201), a primary mirror to adjust the reflection of display image from the projector;

25 identifying (S202), one or more secondary images for further reflection of the display; and

projecting (S203) the final display in alignment with the driver's gaze.

13. The method of dynamically adjusting the heads-up display as claimed in claim 11 or claim 12, comprises obtaining inputs from plurality from vehicle electronic control unit for displaying on the glazing.

- 5 14. A mechanical mounting assembly (600) for holding the one or more mirrors of the plurality of mirrors of the dynamic heads-up display system (100) as claimed in any one of claims 1 to 10, wherein said mechanical mounting assembly (600) comprises:
- one or more corner locator holders (604) configured to hold a mirror (605);
 - plurality of actuators (602) configured to provide linear movement to the
 - 10 corners of said mirror (605), said actuators (602) being mechanically coupled with the each of said one or more corner locator holders (605);
 - a stepper motor (601) mechanically coupled with each said actuators (602), configured to provide incremental linear control to the movement of said actuators (602);
 - 15 a joint (603) mechanically coupled with each of said actuators (602) configured to convert a linear motion of said actuators (602) to facilitate a desired motion;
 - wherein said joint (603) exhibits 12 degrees of freedom; and
 - each of said actuators (602), joint (603) and corner locator holders (604) are mechanically coupled to provide a coordinated dynamic motion of the mirror (605) to
 - 20 redirect a heads-up display image on the glazing.

15. The mechanical mounting assembly (600) as claimed in claim 14, wherein each of corner locator holders (604) are configured to rotate with a rotation of the respective joint (603) and axis of rotation of corner holder (604) is in line with the axis of rotation
- 25 of the respective stepper motor (601).

16. The mechanical assembly (600) as claimed in claim 14 or claim 15, wherein the corners of said mirror (605) are configured to move said mirror (605) linearly with respect to a motion of the actuators (602); and

the direction of alignment of the mirror (605) is in line with a region of projection in the glazing with a center point of the mirror (605) always remaining constant.

- 5 17. The mechanical assembly (600) as claimed in any one of claims 14-16, wherein said desired motion is dependent on signal obtained from the control unit (110).

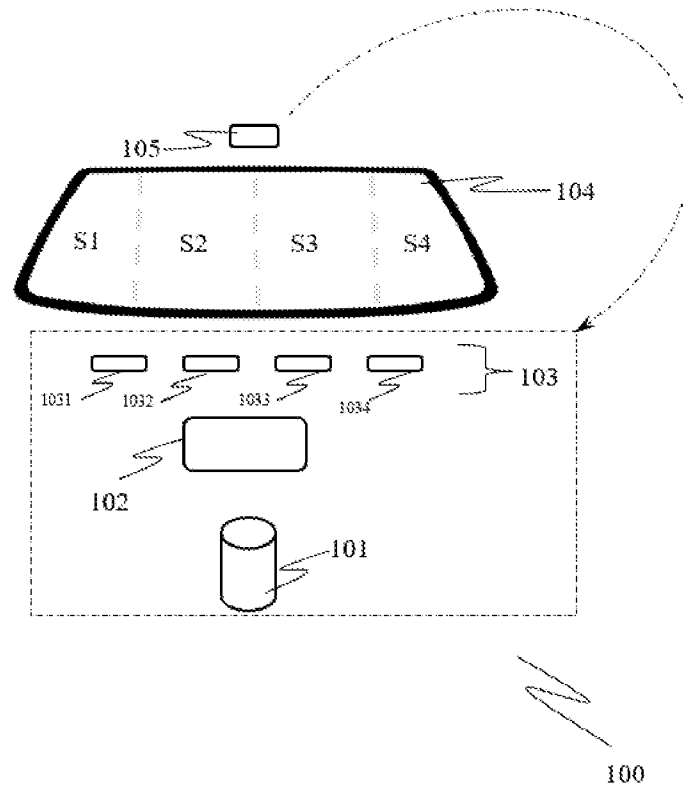


FIG. 1A

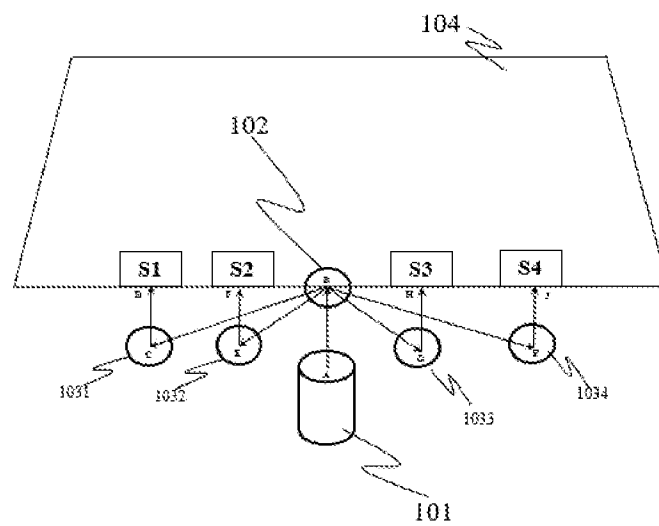


FIG. 1B

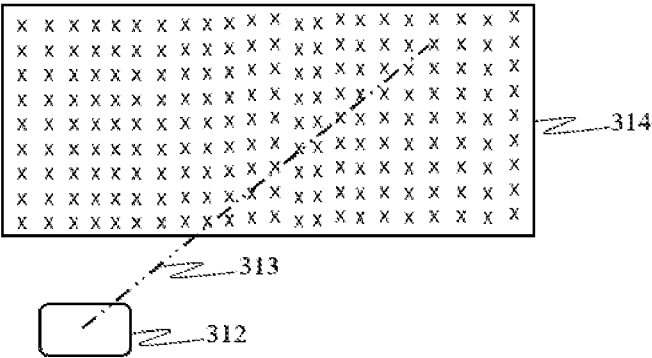


FIG. 2

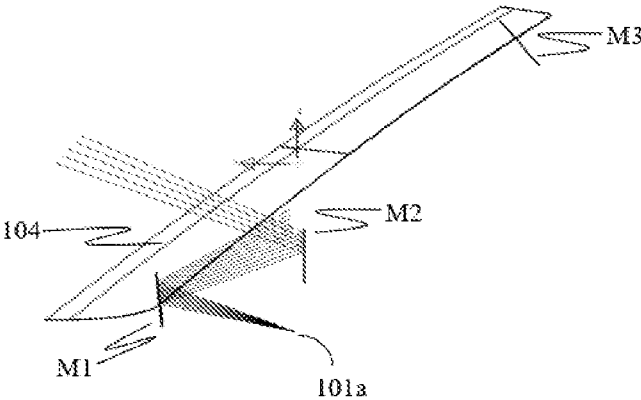


FIG. 3A

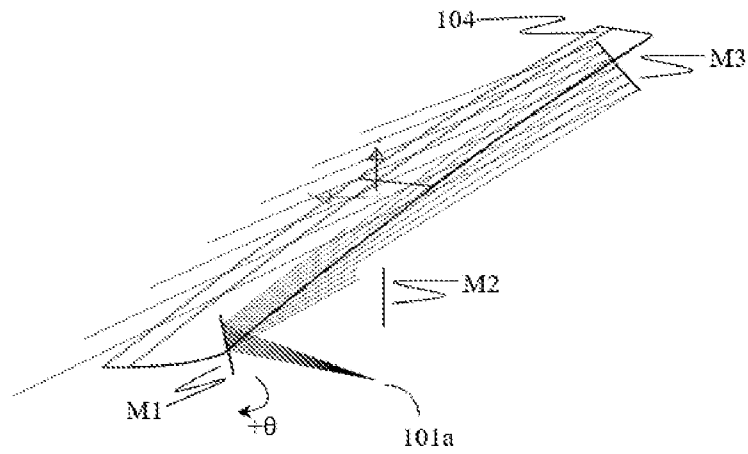


FIG. 3B

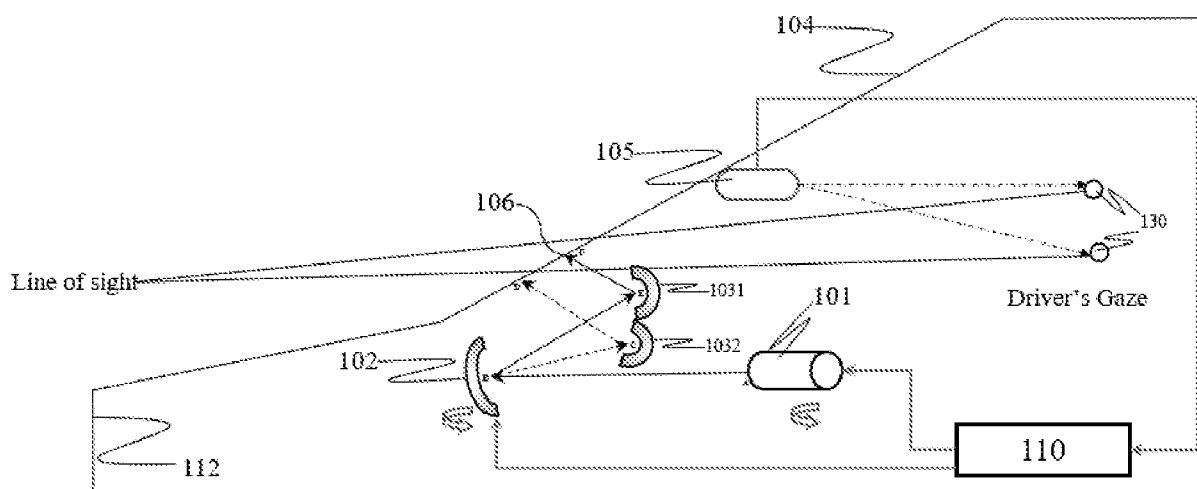


FIG. 4

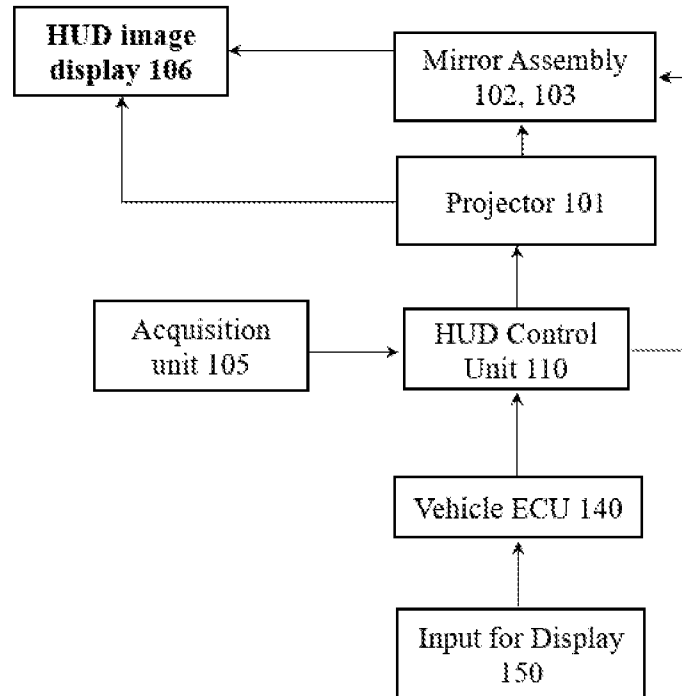


FIG. 5A

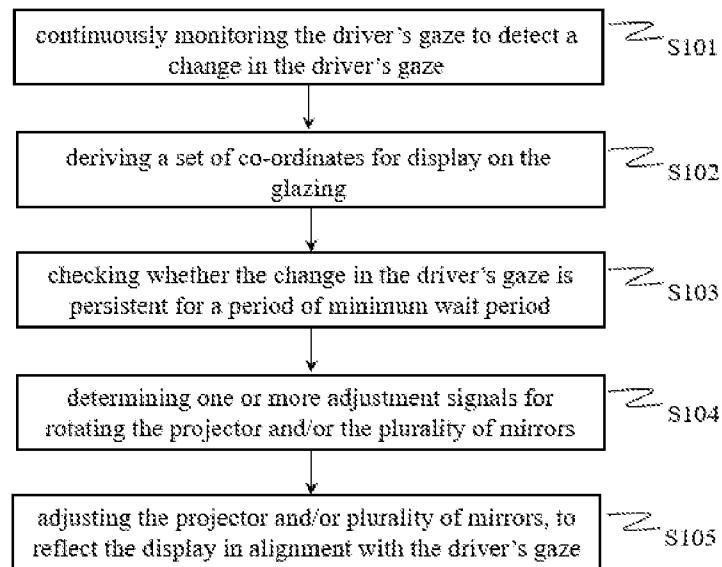


FIG. 5B

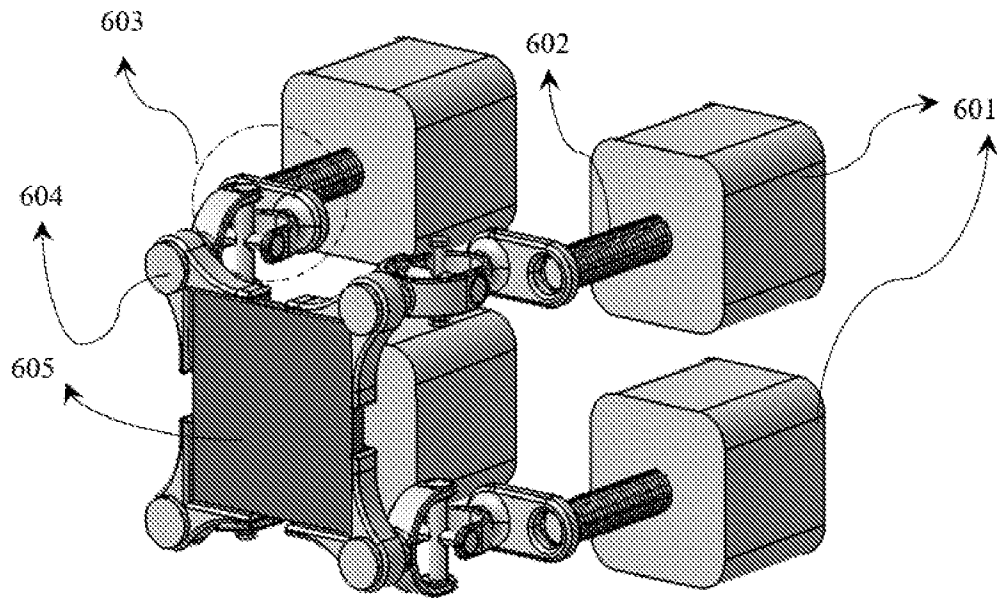


FIG. 6A

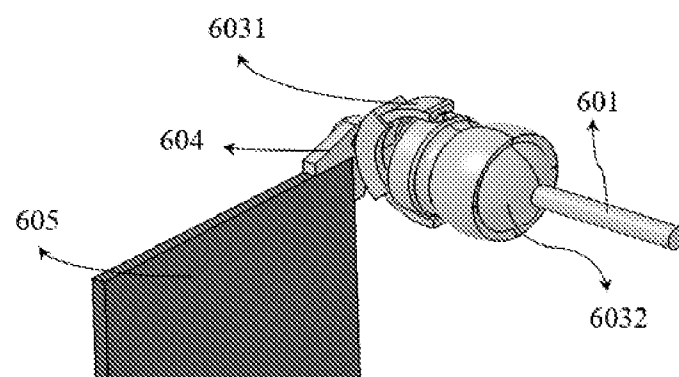


FIG. 6B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IN2024/051281

A. CLASSIFICATION OF SUBJECT MATTER
G02B27/01, B60K35/23 Version=2024.01

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G02B; B60K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of database and, where practicable, search terms used)

Search Databases: PatSeer, IPO Internal Database

Keywords: HUD; mirror assembly; projector; gaze

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US20200320960A1 (YAZAKI CORP) 08.10.2020 (08 October 2020) figures 1, 2, 5, 6, 12 & 14; abstract; paragraphs [0029]–[0032], [0039]–[0050], claim 1	1–17
A	----- CN112558299A (LITE ON TECHNOLOGY CORP) 26.03.2021 (26 March 2021) claims 1, 2, and 5	1–17

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“D” document cited by the applicant in the international application

“E” earlier application or patent but published on or after the international filing date

“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

27-11-2024

Date of mailing of the international search report

27-11-2024

Name and mailing address of the ISA/

Indian Patent Office
Plot No.32, Sector 14, Dwarka, New Delhi-110075
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IN2024/051281

Citation	Pub.Date	Family	Pub.Date
US 2020320960 A1	08-10-2020	US 11367418 B2	21-06-2022
		EP 3730992 B1	01-06-2022
		JP 7005115 B2	21-01-2022
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CN 112558299 A	26-03-2021	US 11250818 B2	15-02-2022
		US 2021097962 A1	01-04-2021