

A HEAD-UP DISPLAY SYSTEM FOR A VEHICLE

Field of the Invention

[0001] The invention relates to a head-up display system for a vehicle.

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Background

[0002] Head-up displays (HUDs) are used to overlay and present information directly in a user's field of view. HUDs are becoming increasingly available in
10 vehicles to superimpose relevant driving information directly into the driver's line of sight or field of view. Modern cars equipped with built-in HUD technology present a viable but expensive solution for drivers.

[0003] A typical built-in HUD system for cars relies on expensive and large
15 optical components (e.g. lens, prisms, mirrors, etc.) so as to form an image with an adequate field of view. Whilst an image with an adequate field of view may be generated, the extensive use of optical components compromises the brightness of the images displayed. Further, the large footprint of the HUD system necessitates substantial modifications to factory-built dashboards in
20 order to accommodate, and conceal the bulky optical components. Apart from the said modifications, further modifications or a custom-built windshield is required to display information onto the windshield. Importantly, such built-in HUD systems are limited in aspects of adjustability and customization required for achieving an ideal view and user experience.

[0004] An add-on or aftermarket HUD system has been proposed, but in a form that only provides a limited field or angle of view. This restriction limits the size of the display, and the range of information that can be superimposed onto the driver's line of sight.

[0005] There is therefore a need to provide a cost-effective aftermarket HUD system for generating virtual images over a wide-angle of view.

10 Summary of the invention

[0006] In accordance with a first aspect of the invention there is provided a head-up display system for a vehicle comprising a display screen; a processor configured to receive display data from one or more input devices; an image projection unit configured to receive the display data from the processor, and to project one or more corresponding images on the display screen; a combiner configured to partially reflect and partially transmit the one or more images from the display screen, wherein the combiner comprises an aspherical surface profile for generating a wide-angle of view.

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[0007] The partially transmissive combiner prevents a resultant virtual image from obstructing the user's view. Hence, this gives the illusion of a floating and partially transparent image superimposed onto the user's otherwise normal view.

[0008] In one embodiment, the actual positioning and size of the head-up display system may be adjustable or fixed to a particular implementation to customise the viewing experience relative to a preferred head to combiner distance, and to human variation in the line of sight. This allows for adjustability
5 and customisation according to user preference, and so avoids the problems inherent with factory-fitted prior art systems.

[0009] Furthermore, the head-up display system of the present invention has a small footprint and so, may be retrofitted easily into existing vehicles without the
10 need for major vehicle modification.

[0010] In some embodiments, the combiner of the head-up display system may comprise a wide-angle aspheric surface configured for uniform magnification of one or more images projected on the display screen.
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[0011] The resultant wide angle view achieved by the wide-angle aspheric surface of the combiner will increase the system's capacity for displaying a wider range of information.

20 **[0012]** In some embodiments, the dimensions and position of the display screen, combiner and image projection unit may be varied accordingly so as to increase or decrease the size of the virtual image. This allows for customisation based on user preferences or the size of the vehicle.

[0013] In some embodiments, the combiner may comprise a photochromic layer or coating. This allows the combiner to darken when exposed to activating light or ultraviolet light present in sunlight, but not in artificial light. The combiner returns to its clear state in the absence of such activating light. To this end, the
5 combiner may advantageously adjust the brightness and contrast of information displayed in respect to the brightness of the background or surroundings.

[0014] In embodiments of the present invention, the head-up display system may comprise one or more software/computer programmes for displaying
10 information in context. For example, the system may be configured to display navigation directions such that they appear superimposed on the road in the user's line of sight. In another exemplary example, the system may be configured to display notifications from a personal communication device such that they appear superimposed at a corner or edge of the user's line of sight.

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[0015] In embodiments of the present invention, the head-up display system may further comprise in-built devices such as an image projection unit, a GPS module and a memory.

20 [0016] In embodiments of the present invention, external devices may be further provided to communicate with the head-up display system. Examples of the external devices may include a personal communication device, dash camera, vehicle's on-board diagnostics system, an external GPS, rear view camera, blind spot camera and user input assembly. The mode of communication

between the external devices and the head-up display system may comprise any available means to connect two devices. For example, the mode of communication may include but is not limited to Bluetooth, Wi-Fi, wired adapters or any other features available to connect an external device such as
5 a personal communication device to another system. This arrangement will allow the head-up display system to draw information from the various external devices so as to display such critical information to the user. Furthermore, the user may be able to customise the type of information they require and the layout of the virtual image projected.

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[0017] In one embodiment, the GPS module allows the head-up display system to be used in an offline mode by allowing the user to perform navigation functions such as to search for locations and provide directions. The information can then be displayed to the user.

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[0018] The head-up display system may also work in an online mode by access an online database such as an online map database. This may be achieved by connecting the system to a mobile data connection, Wi-Fi or any other means to connect a device to the internet.

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[0019] Hence, the above allows the user to switch between online and offline modes to cater for different situations, thereby further improving the adaptability of the head-up display system.

Brief description of the drawings

[0020] It will be convenient to further describe the present invention with respect to the accompanying drawings that illustrate possible arrangements of the invention. Other arrangements of the invention are also possible and consequently, the particularity of the accompanying drawings is not to be understood as superseding the generality of the preceding description of the invention.

10 [0021] Figure 1 is a front perspective view of a set-up for a head-up display system according to an embodiment of the present invention;

[0022] Figure 2 is a side elevation view of a head-up display system of Figure 1 in use by a user;

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[0023] Figure 3 is a plan view of blind spot cameras in use with a head-up display, and vehicle according to an embodiment of the present invention; and

[0024] Figure 4 is a virtual image generated from a head-up display system according to an embodiment of the present invention.

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Detailed description of certain embodiments

[0025] As used herein, the term “vehicle” shall be interpreted as any land-bound vehicle including but not limited to a car, a lorry, a bus, a truck, a train, or a tram.

- 5 **[0026]** As used herein, the term “aspheric” shall be interpreted as a lens whose surface profiles are not portions of a sphere or cylinder.

[0027] As used herein, the term “image distance” shall be interpreted as the distance between a virtual image generated by a head-up display system, and a
10 combiner.

[0028] As used herein, the terms “angle of view” and “field of view” may be used interchangeably.

- 15 **[0029]** As used herein, the term “wide-angle” shall be interpreted as having an angle of view of at least 5 degrees horizontally and 3 degrees vertically.

[0030] Figure 1 shows a set-up for a head-up display system 5 according to an embodiment of the present invention. Figure 2 shows the head-up display
20 system 5 of Figure 1 in use by a user or driver 25 in a vehicle. The head-up display system 5 comprises a display screen 10, an image projection unit 15, a combiner 20 and a processor (not shown).

[0031] The display screen 10, image projection unit 15, combiner 20 and processor of the head-up display system 5 may be mounted in a housing using any suitable mounting structures to form a discrete and self-contained device.

5 **[0032]** To this end, the present invention has a small footprint while achieving the desired result. Importantly, the head-up display system of the present invention may be retrofitted easily into existing vehicles without the need for major vehicle modifications.

10 **[0033]** Further, the combiner and display screen may be mounted to the housing such that they may be stowed away when not in use, and returned to a deployed position for projection and display.

[0034] In a first embodiment, as shown in Figure 2, the display screen 10,
15 image projection unit 15 and combiner 20 may be aligned such that the image projection unit 15 is pointing at the display screen, and disposed in between the display screen 10 and combiner 20 but is off-set therefrom such that reflected rays 70, 75 from the screen 10 and combiner 20 are not obstructed. With this arrangement, a virtual image 30 is generated in the user's 25 line of sight 35, 40.

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[0035] In one embodiment, the display screen 10 may have dimensions in the range of 1.7 inch (43 mm) to 2.4 inch (61 mm) diagonally, with an aspect ratio of 16:10. The combiner 20 may have the dimensions of 140 mm x 70 mm. Further, the image projection unit 15 may be positioned at a distance of 50 mm away

from the display screen 10. However, it will be understood that the dimensions may be varied by a designer or manufacturer based on user requirements. Notably, the magnification and image distance is fixed for a fixed value of projection length, screen size, screen-combiner distance and combiner curvature. However, the designer or manufacturer can change the magnification and/or image distance by changing any of these parameters.

[0036] In one embodiment, the processor may communicate with, and receive display data from one or more input devices prior to further communication of the display data received to the image projection unit 15. The image projection unit 15 then projects one or more images corresponding to the data received on the display screen. The combiner 20 partially reflects and partially transmits the projected images on the display screen at optical infinity. Image 30 illustrates a virtual image appearing uniformly enlarged or magnified to the user 25. Dashed lines 45, 50 show paths along which light is transmitted at optical infinity to form virtual image 30. In other words, image 30 is superimposed onto the user's line of sight and appears to be at infinity, within the same scope of view and focus as far-away real world objects (e.g. roads, traffic, road signs, etc.) outside the vehicle.

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[0037] In this embodiment, the head-up display system may be placed on the dashboard of a vehicle, intermediate the windshield and user. The actual positioning and size of the head-up display system may be adjustable or fixed in

a particular implementation to customize the viewing experience relative to the preferred head to combiner distance, and to human variation in the line of sight.

[0038] To this end, the present invention allows for adjustability and customization according to user experience, and so avoids the problems inherent with factory-fitted prior art systems.

[0039] The head-up display system 5 may further comprise a combiner base pivotally coupled to the combiner 20. For example, the combiner base may be hinged to the combiner. This arrangement allows the user to adjust the angle of the combiner with reference to a vertical axis so as to re-position the final image location according to the comfort of the user.

[0040] In embodiments of the invention, the head-up display system may comprise one or more software and computer programmes for harvesting data from one or more input devices by the processor, and deriving only the important and relevant information for display.

[0041] In one embodiment, image 30 may be uniformly magnified by an enlargement factor of 12. In this embodiment, the magnification of the image 30 is achieved by using a wide-angle combiner having an aspheric surface that acts as a magnifying mirror. To this end, the combiner 20 is thus able to create an image 30 at an image distance of 1500 mm having a wide-angle of view of at least 5 degrees horizontally and 3 degrees vertically.

[0042] To prevent the image 30 from obstructing the user's view, the combiner may also be partially transmissive. For example, 70% of the incident ray may be transmitted through the combiner while 30% of the incident ray may be reflected.

5 This gives the illusion of a floating and partially transparent image in the user's otherwise normal view.

[0043] Whilst a wide-angle of view can be achieved using the afore-described wide-angle aspheric lens, it will be appreciated that a partially clear plastic resin
10 with the same surface profile as the afore-described aspheric lens may also serve the purpose.

[0044] The wide-angle of view provided by the head-up display system of the present invention thus increases the system's capacity for displaying a wider
15 range of information.

[0045] In one embodiment, the head-up display system may comprise one or more software and computer programmes for displaying information in context. For example, the system may be configured to display navigation directions
20 such that it appears superimposed on the road in the user's line of sight. In another example, the system may be configured to display notifications of an incoming phone call or text message such that it appears superimposed at a corner or edge of the user's line of sight (i.e. windshield).

[0046] The combiner according to any embodiment may comprise a photochromic layer or coating such that the combiner darkens when exposed to activating light or ultraviolet light of the intensity present in sunlight, but not in artificial light. In the absence of activating light, the combiner returns to its clear state. To this end, the combiner advantageously adjust brightness and contrast of information displayed in respect to the brightness of the background.

[0047] In an embodiment, the display screen may comprise an opaque and flat screen for displaying a projected image from the image unit projector. The display screen may have dimensions in the range of 1.7 inch (43 mm) to 2.4 (61 mm) inch diagonally, with an aspect ratio of 16:10. It will be appreciated that the dimensions of the display screen and combiner may vary according to the type of image projection unit used, the length of projection and enlargement factor intended.

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[0048] In one embodiment, the image projection unit may comprise a scanned laser pico projector for projecting images in high definition and high resolution. Alternatively, a DLP projector (Texas Instruments) or other projectors may also serve the purpose.

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[0049] In embodiments of the invention, the head-up display may include a rechargeable power supply and a switch. The head-up display may further

include a power cable adaptable to a cigarette lighter socket of a vehicle for charging the head-up display system.

[0050] In an embodiment, the processor may be pre-loaded with any suitable operating system. For example, suitable operating systems may include but are not limited to Microsoft Windows, OS X, Linus and Android.

[0051] It will be appreciated that the system may further include a memory for storing operating instructions and any other relevant data. For example, relevant data may include but are not limited to a map database, recorded images from a camera, data received from the internet and a vehicle's on-board diagnostics (OBD) system.

[0052] In an embodiment, the head-up display system may comprise one or more suitable communication devices for communication, and exchange of data between the processor, and one or more input devices.

[0053] Suitable communication devices may comprise wired and/or wireless communication devices. Examples of wired communication devices may include but are not limited to Universal Serial Bus (USB) ports, micro USB ports and mini USB ports. In addition, examples of wireless communication devices may include but are not limited to a Bluetooth dongle and a corresponding built-in Bluetooth radio, and a wireless access point.

[0054] The input devices may comprise in-built devices within the head-up display system and/or external devices. Examples of in-built devices may include but are not limited to an image projection unit, a GPS module and a memory. In addition, examples of external devices may include but are not
5 limited to a personal communication device, a dash camera, a vehicle's on-board diagnostics system, an external GPS, a rear view camera, a blind spot camera and a user input assembly.

[0055] Further, the personal communication device may comprise any device
10 which is portable and used for communications such as cellular phones, pagers, notebooks, tablets, laptops or personal digital assistants (PDAs).

[0056] In an embodiment, the head-up display may include a user input assembly for receiving a user's input, and transmitting corresponding control
15 signals in response to the user's input to the processor. The control signals are in turn used for operating the head-up display system, and/or interacting with one or more input devices. The user input assembly may comprise one or a combination of a touchscreen, a motion detection sensor and a voice detection sensor.

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[0057] In an embodiment, the head-up display system may communicate with one or more personal communication devices for transmitting functions, notifications, and/or applications from the personal communication device to the processor for display. The functions may comprise any functions available on

the personal communication devices. For example, functions of a personal communication device may include but are not limited to voice call, video call, text messaging, multimedia messaging and email. In addition, examples of notifications and/or applications may include but are not limited to notifications
5 relating to voice call, video call, text messaging, multimedia messaging, email, Google Maps, YouTube, Facebook, Instagram and Tweeter. Further, the mode of communication between the personal communication device and the head-up display system may comprise any available means to connect two devices. For example, the mode of communication may include but is not limited to Bluetooth,
10 Wi-Fi, wired adapters or any other features available to connect a personal communication device to another system.

[0058] In one embodiment, the head-up display system may communicate with one or more blind spot or rear view cameras to transmit the images captured by
15 the cameras to the processor for real time display. Figure 3 shows an exemplary head-up display system in communication with two blind spot cameras 55, 60 in a vehicle 65. Specifically, the field of views 100, 105 may be transmitted from cameras 55, 60 to the head-up display system in real time, and superimposed onto a user's scope of view and focus.

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[0059] In an embodiment, the head-up display system may communicate with a vehicle's on-board diagnostics (OBD) system, and transmit diagnostic information received from the OBD system to the processor for display.

Diagnostic information may include but are not limited to error codes relating to a vehicle's emission equipment, engine and mileage.

[0060] In embodiments of the invention, the head-up display system may
5 include a software and/or programme for decoding one or more error codes received from a vehicle's OBD system based on an error code database or the internet. The system may further transmit one or more definitions corresponding to the error codes to the processor for display.

10 **[0061]** In one embodiment, the head-up display system may comprise a wireless Bluetooth dongle adaptable to a vehicle's on-board diagnostics (e.g. OBD2) port for wireless communication between the system and the vehicle's on-board diagnostics system.

15 **[0062]** In an embodiment, the head-up display system may comprise a GPS module integral of the system. The GPS module may be configured to determine real time information relating to the direction, position and speed of a vehicle, and to transmit the information to the processor for display.

20 **[0063]** In one embodiment, the head-up display system may further comprise an offline map database in which a user can use to display a vehicle's location, provide directions, and allow the user to search for locations using the GPS module in the head-up display system. In this way, the head-up display system may be used in an offline mode.

[0064] Alternatively, the head-up display system may also be used in an online mode by accessing an online map database such as Google Maps or Apple Maps. This can be done through a Mobile data connection, Wi-Fi or any other
5 means to connect a device to the internet.

[0065] In an embodiment, the head-up display system may include software and/or a programme for translating the information received from the GPS module into wire-frame navigation displays, or images with minimal visual
10 content to minimize distractions. Figure 4 shows a virtual image 80 comprising navigation images generated by the head-up display system of an embodiment of the present invention. Specifically, image 80 comprises a wire-frame display
85 of a road map of the vicinity or destination, simplified instructions 90 indicating the next waypoint, and direction 95 of any turn at that waypoint.

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[0066] It will be appreciated that the Google Map application, Apple Map application, or any other similar applications on any personal communication devices in communication with a head-up display of the present invention may serve a similar purpose. Specifically, the images from Google or Apple Map
20 would appear opaque if they are projected directly from the head-up display system, and would have limited usability unless the images are converted to a transparent display. Further, the large amount of spatial and navigation data presented on Google or Apple Map may be disruptive and difficult to comprehend. In this embodiment, the head-up display system of the present

invention advantageously converts the information, and images from the Google Map application, Apple Map application, or any other similar applications into transparent wire-frame navigation displays with minimal content.

Claims

1. A head-up display system for a vehicle comprising:
 - a display screen;
 - a processor configured to receive display data from one or more input
 - 5 devices;
 - an image projection unit configured to receive the display data from the processor, and to project one or more corresponding images on the display screen;
 - a combiner configured to partially reflect and partially transmit the one or
 - 10 more images from the display screen, wherein the combiner comprises an aspherical surface profile for generating a wide-angle of view.
2. The head-up display system according to claim 1, wherein the combiner comprises a wide-angle aspheric surface configured for uniform magnification of
- 15 one or more images projected on the display screen.
3. The head-up display system according to any preceding claim, wherein the combiner is configured to provide an angle of view of at least 5 degrees horizontally and 3 degrees vertically.
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4. The head-up display system according to any preceding claim, wherein the combiner comprises a photochromic layer or coating.

5. The head-up display system according to any preceding claim, wherein the display screen comprises an opaque screen.

6. The head-up display system according to any preceding claim, wherein the
5 system comprises wired and/or wireless communication devices for communication between the processor and one or more input devices.

7. The head-up display system according to any preceding claim, wherein the system comprises a GPS module configured to determine real time information
10 relating to the direction, position and speed of a vehicle, and to transmit the information to the processor for display.

8. The head-up display system according to claim 7, wherein the GPS module is integral to the head-up display system.

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9. The head-up display system according to claim 7 or 8, wherein the GPS module further comprises an offline map database.

10. The head-up display system according to any one of claims 7 to 9, wherein
20 the processor is configured to translate the information received from the GPS module into wire-frame navigation displays with minimal content.

11. The head-up display system according to claim 6, wherein the communication devices are configured to communicate with personal

communication devices, and to transmit functions, notifications, and/or applications from the personal communication devices to the processor for display.

- 5 12. The head-up display system according to any preceding claim, wherein the processor is arranged to operate using any one of the following operating systems: Microsoft Windows, Mac OS X, Linux or Android.

- 10 13. The head-up display system according to claim 6, wherein the communication devices are configured to communicate with one or more blind spot or rear view cameras, and to transmit the images captured by the cameras to the processor for real time display.

- 15 14. The head-up display system according to claim 6, wherein the communication devices are configured to communicate with a vehicle's on-board diagnostics (OBD) system, and to transmit diagnostic information received from the OBD system to the processor for display.

- 20 15. The head-up display system according to claim 14, wherein the system is configured to decode the diagnostic information based on a database and/or the internet, and to transmit a definition corresponding to the diagnostic information to the processor for display.

16. The head-up display system according to claim 13 or 14, wherein the system further comprises a wireless Bluetooth dongle adaptable to an OBD2 port of the vehicle for wireless communication with the head-up display system.

5 17. The head-up display system according to claim 6, wherein the communication devices are configured to communicate with a dash camera, and to transmit the videos recorded to the processor for play back of videos recorded.

10 18. The head-up display system according to any preceding claim, wherein the system further comprises a storage unit for storage of the data received from the one or more input devices.

15 19. The head-up display system according to any preceding claim, wherein the system comprises a user input assembly configured to transmit control signals to the processor in response to a user's inputs for operation of the system, and/or interaction with the one or more input devices.

20 20. The head-up display system according to claim 19, wherein the input assembly comprises one or more of: a touchscreen, a motion detection sensor, and a voice detection sensor.

21. A kit comprising the head-up display system according to any preceding claims, and one or more of: a GPS module, a dash camera, a rear view camera,

a blind spot camera, a wireless Bluetooth dongle for a vehicle OBD system and a user input assembly.

22. A vehicle comprising a head-up display system according to any one of
5 claims 1 to 20.