

Modular Add-on Augmented Reality Head-up Display, Interfaces And Controls

Field of Invention

[001] The present invention relates to a modular add-on augmented reality (AR) head-up display system, associated user interfaces and controls. The user interfaces are intuitive and they add on augmented reality functionalities to a host eyewear (including protective spectacles used by law enforcement, military or rescue personnel, prescription and non-prescription spectacles) and helmet mounted AR spectacles.

Background

[002] A wearable head-up display typically includes a near-eye display or projection member, which is often mounted on a temple piece of an eyewear and displays an image that is visible to the user at an oblique angle whilst the user sees real objects straight through the eye-pieces. These heads-up display systems are useful for mission-critical or time-critical situations in which personnel are provided with or interact with intuitive augmented information about the surrounding so as to allow the personnel to make quick and accurate decisions. Such augmented information is transmitted via intuitive user interfaces (UIs), which minimise cognitive loads when making decisions, sending/receiving information and communicating amongst the personnel in the field, between the personnel and their equipment and/or between the personnel and a remote command centre.

[003] These heads-up display systems are useful for mission-critical or time-critical tasks because the personnel are constantly on the look out and stay vigilant whilst augmented information is made available at an angle to the line of sight, and their hands are always ready on their equipment for action (in so-called heads-up, eyes-out and hands-on trigger concepts). These systems are useful if the systems can be adapted for use with prescription glasses, non-prescription glasses, protective eyewear used by enforcement or rescue personnel, helmet mounted eyewear or safety goggle (ie. host eyewear). Often, the near-eye display or projection member is fixed onto the eyewear and this may obstruct the vision of the user. Also, this eyewear is often not foldable.

[004] It can thus be seen that there exists a need to provide a modular add-on head-up augmented reality functionalities to an eyewear of a host. Preferably, this modular add-on is foldable and the near-eye display or projection member is movable to an unobstructed view position during mission-critical, time-critical or safety-critical situations; these heads-up AR display systems are designed for ease of use and to augment productivity and efficiency during training or work.

Summary

[005] The following presents a simplified summary to provide a basic understanding of the present invention. This summary is not an extensive overview of the invention, and is not intended to identify key features of the invention. Rather, it is to present some of the inventive concepts of this invention in a generalised form as a prelude to the detailed description that is to follow.

[006] The present invention seeks to provide a modular head-up augmented reality (AR) display system to add-on to a host spectacle or an AR spectacle for mounting onto a helmet. Modules of the AR display system are for removeable attachment onto the host spectacle/helmet, and for extending functionalities of the host spectacle, which include multi-modal controls of forward equipment deployed ahead of the user.

[007] In one embodiment, the present invention provides a modular augmented reality head-up display system as defined in claims 1-17.

[008] In another embodiment, the present invention provides a modular augmented reality head-up display kit as defined in claim 18.

[009] In yet another embodiment, the present invention provides a realtime control system for an unmanned vehicle recited in claims 10-15, and an alternative autonomous control system as defined in claims 20-23.

Brief Description of the Drawings

[0010] This invention will be described by way of non-limiting embodiments of the present invention, with reference to the accompanying drawings, in which:

[0011] FIG. 1A illustrates a perspective view of a right-handed modular augmented reality (AR) head-up display system according to an embodiment of the present invention, whilst FIG. 1B shows a plan view; FIG. 1C illustrates the modular AR head-up display system in which the display or projection member is pivoted to an unobstructed view position, and FIG. 1D illustrates the system being folded up; FIG. 1E illustrates a left-handed configuration of the modular AR head-up display system; and FIG. 1F illustrates a drop-in slot connector for pivoted connection of a display or projection module on a processor module.

[0012] FIGs. 2A-2D illustrate a head-up display system mounted on a helmet;

[0013] FIG. 3 illustrates various functionalities of the modular AR head-up display system; and

[0014] FIG. 4A illustrates an AR view seen through the above modular AR head-up display system, whilst FIGs. 4B-4E illustrate other user interfaces of the AR view.

Detailed Description

[0015] One or more specific and alternative embodiments of the present invention will now be described with reference to the attached drawings. It shall be apparent to one skilled in the art, however, that this invention may be practised without such specific details. Some of the details may not be described at length so as not to obscure the present invention.

[0016] FIG. 1A shows a perspective view of a modular head-up display system **100** for removeable attachment onto an eyewear or spectacle **10** of a host. Preferably, the host spectacle **10** is a type of ballistic protection spectacle, safety goggle, non-prescription spectacle and/or a prescription spectacle. The modular head-up display system **100**

includes a processor module **110**, a battery module **170** and a trunking module **180**. The processor and battery modules are attachable onto separate temple pieces **11a**, **11b** of the host spectacle **10** whilst the trunking module **180** is attachable onto a front frame member **12** of the spectacle. When assembled onto the spectacle, the trunking member is located between the processor and battery modules, thereby protecting wires **190** between the battery and processor modules. The battery and processor modules are configured for a right-hand or left-hand user depending on the user and an inside face of each module has a hook **111**, **171** for removeable snapping-on onto the respective temple piece **11a**, **11b**; FIG. 1E shows a plan view of the left-handed configuration **100a** of the modular AR head-up display system. Weights of the battery and processor modules are distributed and balanced to maintain comfortable wearing of the host spectacle.

[0017] The processor module **110** includes an electronic processing unit **115**, a wireless communication unit **120**, a barometer **125**, a pedometer **130**, a nine-axis inertia measuring unit (IMU) **135**, a GPS unit **140**, a touch pad **145** and some select buttons **150**. At a forward distal end of the processor module **110** is a drop-in slot connector **160**, which allows pivotable connection with a display or projection module **200**. The projection module **200** includes a body member **210** and a transparent prism member **260**. The body member **210** houses a micro-display unit **215**, a camera/video unit **220**, a light sensor **225** and a thermal camera **230**. In low light conditions, the camera unit **220** and the thermal camera **230** are both activated, and an image fusion algorithm **232** corrects the outputs of both the camera unit and thermal camera, and provides thermal images with defined outlines to assist the user with night vision; with these thermal images, the user **30** can better identify targets or objects of interest (OoI) **310**; this night vision function can be activated by toggling on a night vision button **332**, as seen in FIG. 4A. In addition, some buttons **240**, **240a** (such as on/off or select buttons) are provided on an upper face of the body member **210**. The transparent prism member **260** has an internal reflection surface on which an image projected from the micro-display unit **215** is formed and is visible to the user **30** by side glancing. FIG. 1B shows a plan view of the head-up display system shown in FIG. 1A, whilst FIG. 1C shows the projection module **200** is moved to an unobstructed position, and FIG. 1D shows the head-up display system with the temple pieces **11a**, **11b** of the spectacle being folded-up. In use, the modular head-up display system **100** may wireless connect to a third party support devices, such as, a laser finder **101**, an acoustic targeting system (ATS) **102** and forward equipment **103** (such as, an unmanned ground

vehicle (UGV) **103a**, an unmanned aerial vehicle (UAV) or drone **103b**, and an unmanned underwater vehicle (UUV) **103c**. In another embodiment, such as that for helmet mounting, the barometer, pedometer, IMU, and so on, may be housed in a separate unit, which is wearable on the user's clothing. In other embodiments, the touch pad **145** can be configured as a tactile track point.

[0018] The modular heads-up display system **100** also includes user interfaces that allow augmented reality information to be provided to the user intuitively (ie. a head-up concept). In other words, during mission-critical, time-critical, or safety-critical moments, augmented information about the surrounding is provided to the user **30** and/or users/peers **32** to allow them to make critical decisions quickly and accurately whilst the user(s) is/are in the frontline (ie. with eyes-out and hands-on trigger concepts). The electronic components in the processor module **110** respond equally quickly and automatically to support these mission-critical, time-critical or safety-critical moments. When the user is in a less pressing moment that the user is able to use the touch pad/track point **145** and select buttons **150** to input data, such as, using **1101** the laser finder **101**, using the forward equipment **103**, taking **1220** photos/videos with the camera/video unit **220**, tagging **1312** objects of interest (OoI) **310** on the photos, navigating the GPS map, sending **1380** information to other users/peers **32** and command centre **20**, and so on. These intuitive user interfaces help to minimize cognitive load on the users **30** so that they can concentrate on mission-critical, time-critical or safety-critical decision making. Thus, with this heads-up display system **100**, the user **30** decision making and task effectiveness and efficiency is enhanced.

[0019] FIG. 1F shows the drop-in slot connector **160** which allows the projection module **200** to click or detent lock in the extended position (in the AR view) or in the retracted position (in the full reality view) until the projection module **200** is moved by the user. The click or detent lock mechanism is provided by two grooves **161** on the processor module **110** and two cooperating projections **162a**, **162b** on the drop-in slot connector **160**. The drop-in slot connector is hollow and allows electrical connection between the processor and display/projection modules. The drop-in slot connector **160** is held in the processor module **110** by two pins **165** as can be visualized in FIG. 1F.

[0020] FIGs. 2A-2D show various views of a modular head-up AR display system **100b** that is mountable on a helmet **15**. As shown in FIGs. 2A-2D, the modular head-up display system **100b** is made up of a battery module **170a** mounted on a Picatinny rail **17**. A trunking module **180a** connects the battery module **170a** to a processor module **110a**, which distal end supports a body **210a** of a projection module **200a**, such that a see-through prism **260a** is proximate to the eye of the user **30**. The Picatinny rail **17** allows the AR display system **100b** to be mounted or dismounted with ease. In FIGs. 2A-2D, the AR display system **100b** is shown for left-hand mounting on the helmet **15**; this AR display system can also be configured for mounting on the right hand side of a helmet. The functions and components of the processor module **110a**, trunking module **180a** and battery module **170a** are similar to those described above; for eg., on the processor module, there are: a tactile track point **145a**, an on/off button **240**, a select button **240a**, and so on. On the projection body **210a**, there are: a camera/video unit **220a**, a light sensor **225a** and a thermal sensor **230a**.

[0021] FIG. 3 shows various functionalities of the above modular heads-up display system **100, 100a, 100b** whilst FIGs. 4A-4E show various view modes **300, 301, 302, 303, 304** of the user interfaces. A default AR view mode **300** allows the user to see-through the spectacle **10** for identifying OoI **310** (ie. reality view **300a**) and be provided with AR information. As seen in FIG. 4A, with the camera **220** set in video taking as the default mode, video is presented near the centre of the AR view where a man-identification algorithm **116** in the electronic processing unit **115** is provided to identify and to mark/highlight **1310** a human face **310** in the video. Automatic marking of a human face in the frontline vision helps to locate a target or to warn the user of a potential threat. The human feature identified in the video can also be tagged, for eg, with an icon **312** and may be additionally distinguished as a friend/peer **32** or foe **34**. The tagging functionality may be supported by a tagging algorithm **118** disposed inside the processor unit **110**. At the same time, a bottom right side of the AR view is a minimized GPS map **320** view of the surrounding. The position of the human feature or any OoI **310** can be planted on the GPS map **320** by firing a laser finder **101** at the target and obtaining estimates of distance and location coordinates from the user position. Preferably, the minimized GPS map view occupies about 25% of the entire AR view. On the left hand edge of the AR view, there are 6 view mode buttons/icons **331, 332, 333, 334, 335, 336**, respectively for activating the camera/video unit **220**, activating the thermal camera **230**, activating a forward equipment

103 (such as controlling a turret or camera of an unmanned vehicle, including an UGV (unmanned ground vehicle) **103a**, UAV (unmanned aerial vehicle) or drone **103b** or UUV (unmanned underwater vehicle) **103c**), interfacing with third party support devices **101**, **102**, activating an emergency hotkey **335** to communicate with the command centre **20** and logging out **1336** of the AR mode **300**. Across the top of the default AR video view mode is an incoming message panel **350** that pops up an incoming message from other user/peer **32** or the command centre to the user **30**. When a user wears a vest with a health monitor and battery power sensor, health conditions of the user (such as, body temperature **391**, health state **392** (like, tired, exhausted, heat stroke, etc.) and electric power level **393** may be displayed in a health and supplies panel **390** located on the right hand side of the AR view mode. Preferably, when a view mode button/icon is active, its colour toggles, for eg. to grey.

[0022] In the default AR view mode **300**, the camera **220** can be activated to take **1220** video or photo **310** by activating the camera icon **331** or button **240** on the projection body **210**. With a photo taken, the user can activate the touch pad/track point **145**, move a highlight box to select a target or OoI **310**, click within the highlight box to attach **1312** a tag or icon **312**. Alternatively, the entire photo **310** can be tagged. If the user takes no action after capturing a photo, the view mode reverts to the default AR video mode after a lapse of a predetermined time, such as about 10 s; alternatively, when the user does not need to tag a target or OoI, the user can click on a cancel button on the touch pad **145** to switch immediately to the default AR video mode. If the touch pad is still active, the predetermined view mode toggling will not take place and the user can continue tagging other targets or OoIs. The predetermined view mode toggle will occur when the AR display system detects inactivity from the user. The videos, photos and tagged photos **310** are sent to the command centre **20** for recording and analyzing.

[0023] In dim light situation or night time, the user **30** can activate the camera **220** and thermal camera **230** for assisted night vision. As in the default video view mode, the man-identification algorithm **116** automatically helps to identify and to mark/highlight a human face **310** in the field of vision to lessen visual cognitive load on the user.

[0024] FIG. 4B shows a turret view **301** when a forward equipment **103** (such as a camera, remote detectors, etc.) of an UGV **103a**, UAV/drone **103b** or UUV **103c** is deployed in the

frontline ahead of the user. When the turret button/icon **333** is activated, the forward equipment is automatically paired with the modular AR display system **100,100a,100b**. When pairing is not successful, the user has the option to reconnect the pairing; if the pairing fails, the user or command centre is notified. In the turret view **301**, a sighting cross-hair **360** appears in the centre of the video streamed from the forward equipment (or camera/detector) mounted on the unmanned vehicle **103**. Pan and tilt movements of the forward equipment's turret directions are controlled by outputs of the 9-axis IMU **135** by moving the head of the user in realtime (ie. requiring substantially continuous, manual inputs to actuators and sensors in the forward equipment). Alternatively, gesture control and/or brain sensory control may be used to control movements of the forward equipment **103** in an autonomous mode, thereby allowing heads-up, eyes-out and hands-on readiness. A multi-modal controller **400** in association with control of the drone **103b** will be described in a later section.

[0025] Clicking on the minimised GPS map **320** brings up the full GPS map view in a new view. FIG. 4C shows the full GPS map view **302**. In the GPS map view, the user **30** is identified by a circle with an apex of a triangle **31** indicating the direction the user is facing as enabled by the GPS unit **140** and 9-axis IMU **135**. For eg., peers or friends **32** are identified by water-drop location pin, whilst foes **34** are identified by quadrilateral speech location pin. On the right hand edge are 4 buttons **361, 362, 363, 364**, respectively for returning to the default view mode, for zooming in, zooming out and refreshing the GPS map. A user can tap on the peer location pin to send **1380** a message (text, icon, photo or video). On tapping a peer location, a keypad (such as that shown in FIG. 4E) appears for the user to enter and send the message. Refreshing updates location of the tagged, peer/friends and foes locations from the last viewing position (instead of refreshing from the user's location).

[0026] When a user enters an indoor area, GPS communication is lost and the user is directed to an indoor navigation mode. From the last known GPS coordinates and direction, the pedometer **130** provides the user with the distances moved, even by the rates of movements, whilst the 9-axis IMU **135** provides the directional changes and the barometer **125** provides the ascending and descending distances.

[0027] FIG. 4D shows a third party support device view mode **303**. The third party support device may be a laser finder **101** or an ATS **102**. With the use of the ATS, a clock face **370** visually shows positions of the targets or OoI **310**, with concentric circles indicating distances from the user and an apex of a triangle **371** at the centre shows the direction the user is facing. The user has the option to tag **312** a target location within the predetermined view mode toggle time. These known target locations and tags are automatically planted on the GPS map **320** and are made available to other users/peers **32** and the command centre **20**.

[0028] Preferably, after tagging a target or OoI **310** position, the modular AR display system **100,100a,100b** automatically switches to the photo taking view mode. The AR display system switches over to the default AR video mode **300** after the predetermined time or the user has the option to cancel the photo taking view mode to immediately switch to the default AR video view mode.

[0029] FIG. 4E shows an emergency view mode **304** of the user interface for communicating with the command centre **20**. In the emergency view mode **304**, text and/or icons are selected from a keypad **380** to compose **1380** messages in an input view panel **382**. The message is sent by activating a send button **384**. In addition, the camera **220** can be activated to provide live video of the frontline surrounding. In the situation when the user **30** requires assistance or attention, the camera **220** can also be programmed to provide live video stream to the command centre **20**.

[0030] Communication with other users/peers, with the forward equipment, with the third party support devices and with the command centre may be via secure wireless connection. As described above, the incoming message panel **350** pops up at the top of the default AR video view mode **300**. There is a tick button **352** near the incoming message panel **350** for the user to acknowledge receipt; if no acknowledgement is made, the incoming message panel **350** fades away after a predetermined time, such as about 15 s. The incoming message panel disappears immediately after acknowledging receipt. To send a message to a peer/friend, the user clicks on the GPS map **320** and clicks on the relevant position icon representing the peer/friend and a message panel similar to that in FIG. 4E appears.

[0031] Now, the modular heads-up display system **100,100a,100b** is described to bring out more clearly each of the various functionalities: (1): Feeding of intuitive AR information to users **30, 32** to help improve situation awareness and to allow better decision making. The user interfaces help in minimizing the cognitive load on the users so as to lessen the burden on the users in making a decision by providing AR information in an intuitive manner and to lessen the demand on them to capture and to send information at the frontline to other users/peers and command centre. In addition, various view modes in the user interface allow the users to quickly switch to the various functionalities, such as:

- (a) Default AR view **300** – allows users to see through the spectacle in the eyes-out and heads-up concepts with constant view of the real surrounding and stay vigilant, with hands-on trigger readiness for action whilst receiving AR information for decision making;
- (b) Night vision button **332** – allows users to use the heads-up display system in dim light environment;
- (c) Forward equipment **103** interaction **333** with man-identification algorithm **116** for identifying humans in videos of forward (or frontline) surrounding some distances away from the users;
- (d) Tagging **1312** of humans identified as peers/friends or foes in videos of frontline surrounding;
- (e) GPS map view **302** – allows users to appraise frontline surrounding by using location maps through GPS and to help in user navigation and communication with peers/friends **32**;
- (f) Interface with third party support devices (such as, ATS and laser finders) to trace and to locate hostile or target **34** locations on the GPS map;
- (g) messaging interface **304** – allows users to communicate and coordinate with other users/peers in the frontline and with the command centre; and
- (h) Emergency hotkey **335** – for contacting or alerting the command centre during an emergency.

[0032] (2) Identification for danger sensing (in the default AR video view mode):

- (a) with the man-identification algorithm **116**, automatically detects and identifies a human face from the video of the frontline surrounding and to mark/highlight the detected human whether they are friends/peers **32** or foes (targets) **34**;
- (b) from this video view mode, users can activate the camera/video **220** button to take photos or videos of the frontline environment to assist other users and the command centre;

- (c) users can activate third party support devices (such as, a laser finder **101** to fire at target positions for automatic planting of target locations/coordinates onto the GPS map **320** so that AR information can be shared with other users and the command centre; and
- (d) turns **1332** on the night vision when the surrounding is dim.

[0033] (3) GPS map view mode **302** allows:

- (a) automatic identification of locations of user and peers/friends **32** in the frontline. This visual broad view of the frontline surrounding lessens the cognitive load on the user; and
- (b) targets/foes **34** locations identified through third party support devices are also automatically planted on the GPS map, thus helping the user to navigate in the field and to communicate with other users/peers and with the command centre.

[0034] (4) Digital tagging of OoI for identification and tracking:

- (a) tagging **1312** allows digitally labeling of targets **310** onto videos or photos captured with the camera/video function;
- (b) tagged information can be in the form of text message or represented by icons or logos **312**;
- (c) tagged information is reflected in the GPS maps for sharing with other users and command centre; and
- (d) instructions and messages from the command centre are received and read by each user in the incoming message panel **350** that is prominently shown across the top of the AR view.

[0035] (5) Forward equipment **103** interaction:

- (a) the forward equipment includes camera/video mounted on or detectors sent by unmanned vehicle **103a**, **103b**, **103c** deployed ahead of the user;
- (b) with outputs from the 9-axis IMU **135**, users can control movement of the unmanned vehicle **103**, for eg., by realtime panning and tilting turrets of the forward equipment; or using a multi-modal controller **400** for autonomous control of a drone or UAV **103b**;
- (c) the camera **220** provides live video streams of the frontline surrounding to assist other users and the command centre; and
- (d) planting and activating remote detectors to assist in user navigation.

[0036] (6) Interface with third party support devices to trace/locate and identify hostile or targets:

- (a) the clock face display **370** provides visual information, such as, the angle, range and position of friends/peers **32** and foes/targets **34** at the frontline. Positions of foes can be traced from detecting hostile gunfires using third party devices like the ATS **102**; and
- (b) with the help of laser finders **101**, users can locate foes/targets coordinates and these locations are planted onto the GPS maps **320**.

[0037] (7) Communication and coordination with the command centre: Users at the frontline may not have a complete view of the surrounding, for eg. due to nature of terrain and structural obstruction, thereby needing support from the command centre, in the form of non-verbal and non-line of sight information of strategic place-of-interest (PoI) or certain OoIs:

- (a) The command centre receives information from other users at the frontline and can thus disseminate information (such as, messages (text or icons) and AR photos/videos to users for better coordination;
- (b) users are also able to send messages (text or icons) and photos/videos to the command centre and other users for sharing information and communicating with one another;
- (c) information history is tracked by time stamping as frontline situations are fast changing; and
- (d) the hotkey **335** for emergency contact with the command centre is provided as a button on the left hand edge of the default AR view. The hotkey allows users to seek quick assistance and attention from the command centre.

[0038] (8) AR heads-up display on host spectacles: The host eyewear **10** is preferably a ballistic protection spectacle, such as those conforming to US military requirements. This modular heads-up display system **100,100a,100b** provides up-to-date information to users at the frontline for making mission-critical, time-critical or safety-critical decisions and coordinating with each other and with the command centre.

[0039] (9) Modular add-on functionalities to host spectacle: The modular heads-up display system **100, 100a** thus extends the functionalities of the host spectacle **10** by removeable snapping on the three modules **110, 170, 180** onto the host spectacle. Users have a choice of right- and left-hand configurations. The display or projection module **200** is pivotable

between an extended position and a retracted position; at the retracted position, the projection module is out of the line of sight through the host spectacle and this gives the user full reality view (or un-obstructed view) of the frontline. In addition, the lengths of the battery and processor modules are kept small, for eg, within substantially 65 mm so that even when the heads-up display system **100, 100a** is attached onto the host spectacle, the temple pieces can be folded and the spectacle can be kept away when not in use.

[0040] (10) Health monitor and electric power sensor. When the user wears a vest with health monitoring, the user is made aware of the state of health (such as body temperature **391**) and be warned of any unhealthy symptoms **392** via the health monitor and supplies panel **390**; when the vest is also equipped with battery power sensing, the user can check the battery power level **393**, even before setting out on a task.

[0041] Typically, a drone **103b** requires more complex controls from a user; generally, a conventional drone controller also requires both hands of a user to operate when navigating the drone. In the following description, the multimodal controller **400** is now described for use to control a drone **103b**, which is deployed as a forward equipment **103** in the frontline. The multimodal controller **400** includes a command integration unit **410** and a command priority weighting unit **414**. In the present invention, the users are often called to execute mission-critical, time-critical or safety-critical tasks; the multimodal controller **400** thus allows a user natural, intuitive and autonomous control of a drone, yet allowing the user to stay vigilant with heads-up, eyes-out and hands-on trigger readiness (with the drone control not requiring both hands to operate); at the same time, with AR information being presented to the user or made available to the user, this heads-up AR system **100,100a,100b** enhances the user's task effectiveness and efficiency. In addition, the multimodal controller **400** adapts to the user (instead of the user having to adapt to the controller, as the case for the conventional drone controller).

[0042] The command integration unit **410** fuses three control modes, namely, voice, gesture and brain signals **420,430,440** to generate an autonomous command signal; in response, the drone executes the autonomous command signal and incrementally updates its state; for eg., by executing a "turn" autonomous command signal, the drone navigates a predetermined distance in an azimuth direction from a present position. In another eg., by executing an "up" autonomous command signal, the drone moves up a predetermined

altitude from its present position. With this autonomous control, during a critical moment, a user can continue to hold a weapon with both hands, with eyes-out and staying vigilant whilst navigating the drone. This autonomous control with predetermined motion and direction is distinguished from the realtime control provided by outputs from the IMU **135**. Further, the user has a choice of initiating a voice control **1420** (where a certain degree of sound is acceptable), gesture control **1430** (using hand signals or inertia of a wearable device) or brain sensory control **1440** (during silent watch). Each of these three controls has respective characteristics of response time, accuracy and sensitivity, and they augment each other (instead of creating redundancies). In this way, the command integration unit **410** is driven by a dominant control mode in one particular state according to its characteristic response time, accuracy, sensitivity and environment compatibility, thereby dispensing with any need for command error correction. This also prevents commands from two different modes being treated as two distinct commands, which would result in unwanted movements of the drone, for eg., when the beginning part of a command stream from a mode with short response/process time catches an ending part of a command stream with longer response/process time. In one embodiment, the command integration unit **410** operates on a rule-based mechanism (for eg., by comparing a current state of the drone with the state of the drone when command signals were received).

[0043] In addition, sensitivities of the different input modes of control are different; for eg., some input modes are error-prone to the environment, such as, noise level and lighting condition, whilst other modes are subject to mental distractions. The command priority weighting unit **414** determines the most appropriate command generated from the three control modes.

[0044] In the multimodal controller, priority weighting unit **414** is given to the control mode which gives the highest sensitivity under a particular environment. For eg., in an environment where brightness is low, gesture control **1430** will be given low weightage in generating the command signal. However, the user can over-ride the command mode. A reason for giving the user this authority is because the user is often able to assess the most suitable control mode in a given environment. For eg., the user can switch to use brain sensory control **1440** for commanding the drone in an environment where voice control **1420** was given the highest priority where a noisy environment could cause a false signal to mix in.

[0045] While specific embodiments have been described and illustrated, it is understood that many changes, modifications, variations and combinations thereof could be made to the present invention without departing from the scope of the invention. For eg., the electronic processing unit includes encryption and decryption algorithms which allow secure coding and decoding of messages and communication. In another eg., a consumer can use the above heads-up display system **100,100a,100b** to improve productivity when conducting a training during which information is provided to the trainer in the AR form; this can also be used during a test or training simulation, or by a pilot, driver or rider when navigating a vehicle, be it aerial, ground or underwater.

CLAIMS:

1. A heads-up augmented reality (AR) display system wearable by a user in a rescue or combat mission comprising:

a processor module;

a battery module;

a trunking module disposed between the processor and the battery modules to protect wires connecting the processor and the battery modules; and

a host spectacle having two temple pieces and a front frame;

wherein the processor and the battery modules have hooks so that the processor and the battery modules are removeably attachable onto separate temple pieces whilst the trunking module is removeably attachable onto the front frame of the host spectacle; and

wherein a forward distal end of the processor module is pivotably connected to a display or projection unit by a drop-in slot connector, so that the display/projection unit is pivotable about one axis and is adjustable between an extended position (for AR view) and a retracted position (for full reality view), thereby allowing the user to stay vigilant during a mission-critical, time-critical or safety-critical situation.

2. The AR heads-up display system according to claim 1, wherein the host spectacle is a ballistic protection eyewear, a prescription eyewear or a non-prescription eyewear.

3. A heads-up augmented reality (AR) display system wearable by a user in a rescue or combat mission comprising:

a processor module;

a battery module; and

a helmet with a Picatinny rail disposed on either exterior side of the helmet for mounting the processor module and the battery module;

wherein a forward distal end of the processor module is pivotably connected to a display or projection unit by a drop-in slot connector, so that the display/projection unit is pivotable about one axis and is adjustable between an extended position (for AR view) and a retracted position (for full reality view), thereby allowing the user to stay vigilant during a mission-critical, time-critical or safety-critical situation.

4. The AR heads-up display system according to any one of claims 1-3, wherein the processor module comprises an electronic processing unit, a barometer, a pedometer, a nine-axis inertia measuring unit (IMU), a GPS unit, a wireless communication unit, a touch pad/track point and some select buttons.
5. The AR heads-up display system according to claim 4, wherein the barometer, the pedometer and IMU are housed in a separate wearable unit.
6. The AR heads-up display system according to any one of the preceding claims, wherein the projection unit comprises a body member and a transparent prism member, with the transparent prism member having an internal reflection surface on which a projection image is formed, and the body member comprises a micro-display unit, a camera/video unit, a light sensor and a thermal camera.
7. The AR heads-up display system according to any one of the claims 1-2 or 4-6, wherein the host spectacle is foldable with the AR heads-up display system attached thereon.
8. The AR heads-up display system according to any one of claims 6-7, wherein the electronic processing unit comprises a man-identification algorithm for detecting a humanoid face when viewing through the camera/video unit.
9. The AR heads-up display system according to claim 8, further comprising a tagging algorithm to allow a user to tag a detected humanoid, any object-of interest (OoI), place-of interest (PoI) or target.
10. The AR heads-up display system according to any one of the claims 4-9 is configured to connect wirelessly with a third party support device, which comprises:
 - (a) a forward equipment having a camera/video or remote detector mounted on an unmanned vehicle deployed ahead of the user;
 - (b) a laser finder for obtaining a distance and coordinates of a target position, and planting the target position onto a GPS map;

- (c) an acoustic targeting system (ATS) for detecting a hostile target position and planting the target position onto a GPS map; or
- (d) a health monitor and battery power sensor, which are disposed in a vest worn by the user.

11. The AR heads-up display system according to any one of claims 4-10, wherein the electronic processing unit generates a user interface showing at least the following view modes:

- (a) default video AR view mode;
- (b) night vision view mode;
- (c) a forward equipment control of a forward unmanned vehicle;
- (d) a GPS map view mode;
- (e) an acoustic targeting system (ATS) view mode;
- (f) an emergency hotkey messaging view mode; or
- (g) user's health conditions and supplies/battery power supply level.

12. The AR heads-up display system according to any one of claims 4-11, wherein outdoor navigation is via GPS, and indoor navigation is traced from the last GPS position, a direction given by a horizontal distance moved, and a rate of horizontal movement obtained via the pedometer, by an ascent or descent distance moved via the barometer, and by directional changes obtained via the IMU.

13. The AR heads-up display system according to claim 12, wherein an emergency user situation is detected by lack of motion within a predetermined time period from the last known GPS coordinates or outputs from the pedometer, barometer or IMU.

14. The AR heads-up display system according to claim 13 is operable to switch to the default video mode to send live video of the surrounding to a command centre (in an emergency situation).

15. The AR heads-up display system according to claim 10, wherein the unmanned vehicle is a drone and a multi-modal controller allows the user to command the drone via voice control, gesture control or brain sensory control.

16. The AR heads-up display system according to claim 15, wherein the multi-modal controller comprises a command integration unit and a command priority weighting unit.

17. The AR heads-up display system according to claim 11, wherein the night vision view activates both the camera unit and the thermal camera, and an image fusion algorithm corrects the outputs of both the camera unit and the thermal camera, and provides a thermal image with defined outlines to assist the user with low light condition.

18. An augmented reality heads-up display kit configurable for a user in a rescue or combat mission comprising:

a processor module;

a battery module;

a trunking module to protect wires connecting the processor and the battery modules;

a host spectacle having two temple pieces and a front frame that supports two lenses, wherein the processor and the battery modules have hooks to removeably snap onto separate temple pieces while the trunking module is removeably attachable onto the front frame; and

a display or projection unit being pivotably connected to a forward distal end of the processor module by a drop-in slot connector, thereby allowing the display/projection unit to pivot about one axis and to adjust between an extended position (for AR view) and a retracted position (for full reality view).

19. An augmented reality heads-up display kit configurable for a user in a rescue or combat mission comprising:

a processor module;

a battery module;

a display or projection unit being pivotably connected to a forward distal end of the processor module by a drop-in slot connector, thereby allowing the display/projection unit to pivot about one axis and to adjust between an extended position (for AR view) and a retracted position (for full reality view);

a helmet; and

a Picatinny rail for mounting on either exterior side of the helmet, and the Picatinny rail, in turn, for mounting the processor module and the battery module.

20. A heads-up augmented reality (AR) assisted control system for an unmanned vehicle deployed in a rescue or combat mission, the control system comprising:

closed loop communication between the unmanned vehicle and an inertia measuring unit (IMU) configured in an associated heads-up AR system according to any one of claims 1-19, wherein movements of the IMU provide realtime inputs to associated actuators and sensors in the unmanned vehicle, whilst the associated actuators and sensors provide realtime feedback, so that positions and orientations of the unmanned vehicle can be verified and allows a user to maintain vigilance with heads-up, eyes-out and hands-on readiness.

21. A heads-up augmented reality (AR) assisted control system for an unmanned vehicle deployed in a rescue or combat mission, the control system comprising:

closed loop communication between the unmanned vehicle and a multi-modal controller configured in an associated heads-up AR system according to any one of claims 1-19, wherein voice, gesture or brain sensory signals send autonomous commands to associated actuators and sensors in the unmanned vehicle, so that the associated actuators are activated to execute predefined, incremental motions, thereby allowing a user to maintain vigilance with heads-up, eyes-out and hands-on readiness.

22. The control system according to claim 21, wherein the multi-modal controller is operable to perform command integration and command priority weightage on the voice, gesture and brain sensory signals.

23. The control system according to claim 22, wherein the command priority weightage allows the user to over-ride the signal mode of the multi-modal controller.

Modular Add-on Augmented Reality Head-up Display, Interfaces and Controls

Abstract

The present invention provides a modular heads-up augmented reality (AR) display system (100,100a,100b) that is removeably attached onto a host spectacle (10) or onto a helmet (15). The AR display system includes a processor module (110), a battery module (170), a trunking module (180) disposed between the processor and battery, and a display (projection) module (200). The display (projection) module is pivoted onto the processor module in an extended position (to provide AR view 300) or in a retracted position (for full reality view 300a). User interfaces of the AR display modes are intuitive and help to reduce cognitive load on the user. The AR display system provides a choice of realtime or autonomous control of an unmanned forward equipment (103). When configured for autonomous control a drone (103b), a multi-modal controller (400) allows the user a choice of voice control (1420), gesture control (1430) or brain sensory control (1440).

FIG. 1A for publication