(57) Abstract: A augmented-reality helmet comprises a full-face motorcycle helmet (10) with a look-down micro-display (24) that projects a virtual image in-line with the helmet’s chin bar (16). In order to accommodate the power requirements, the helmet includes a battery pack (80) mounted at the base of the motorcyclist’s skull. A wind turbine (86) charges the batteries. Exhaust from the turbine is then deducted through the helmet to cool the battery pack and/or the motorcyclist’s head. The turbine is controllable so that it can operate as a circulating fan to provide ventilation. A rear-view camera (60) is mounted within an aerodynamic fairing (64) on the back of the helmet.
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AUGMENTED REALITY MOTORCYCLE HELMET

BACKGROUND OF THE INVENTION

[001] This invention relates generally to display systems for helmets and in particular for display systems for motorcycle helmets.

[002] Heads-up displays have been suggested for implementation in a multitude of transportation applications including automobiles, aircraft and motorcycles. Heads-up displays typically comprise an image projector, an optical collimator; and a beam splitter (combiner). The beam splitter is typically an angled flat piece of transparent or partially reflective material located directly in front of the viewer. The beam splitter reflects the image from the image projector in such a way that the user is able to see the field of view and the projected image at the same time. The optical collimator focuses the image from the image projector into parallel rays of light so that the user sees a virtual image that appears to be at an infinite distance.

[003] The necessity of having a beam splitter as part of a heads-up display causes little inconvenience in automobiles and aircraft where there is a significant amount of space between the user and the front windscreen of the vehicle within which to mount the beam splitter. For motorcycles, however, installing a beam splitter in the limited space between the rider's face and the helmet windscreen presents significant design obstacles. US patent 5,537,092 issued to Suzuki et al. suggests simplifying the information displayed to a motorcycle rider (e.g. by using a linear array of LEDs) and projecting it as a virtual image along the base of the visor (partially obstructing the field of view) as a means of overcoming the space limitations inherent in helmet information displays. This approach, however, severely limits the amount of information that can be communicated to the motorcycle rider and results in a reduction of the rider's field of view.
Additionally, as the demand for more and more real-time display of information increases, the processor speed and power consumption necessary to accommodate the demands also increases. In a wireless environment, this dictates the need for larger and heavier batteries in the helmet battery pack, use of tethered batteries and/or powering the helmet with a cable from the vehicle power system. US patent application 2009/0109292 to Ennis for example discloses a video camera system including a heads-up display that is operated from a battery belt pack connected to the camera by a cable. This is not an ideal implementation for a motorcycle helmet since a cable connected between the motorcyclist's helmet and a belt-mounted battery would be cumbersome especially with the exposed cable subjected to windblast at high speeds.

SUMMARY OF THE INVENTION

The present invention comprises a helmet having a battery-operated augmented reality display. According to an illustrative embodiment, the helmet comprises a full-face motorcycle helmet with a look-down micro-display that projects a virtual image in-line with the helmet's chin bar (which is space that is already obstructed from the motorcyclist's field of view.) In order to accommodate the power requirements of the micro-display and associated processor, a battery pack consisting of 4 lithium ion batteries each rated at 2200 mAh for a total capacity of 8800 mAh housed within a crescent-shaped housing that is attached to the rear of helmet at the base of the motorcyclist's skull. This unique battery mounting position puts the center of mass of the helmet as close as possible to the base of the neck so that, despite the mass of the batteries, the helmet provides little inertial resistance to quick movements of the head. In the illustrative embodiment, the helmet includes a wind turbine that operates to charge the batteries when the helmet is exposed to a wind blast of greater than approximately 10 mph.
Exhaust from the turbine is then deducted through the helmet to cool the battery pack and/or the motorcyclist's head. The turbine is controllable so that at low speeds and high ambient temperatures the turbine operates as a circulating fan to provide ventilation to cool the motorcyclist's head. The helmet further includes a three-axis digital gyroscope mounted to the helmet controller board which (1) provides a control input to a controller for operating a steerable headlight of the motorcycle to track the rider's head movements; and (2) in the event of a rapid deceleration possibly indicating an accident, provides acceleration output to an algorithm that will contact emergency responders if the rider is non-responsive. In the illustrative embodiment, the helmet further comprises a 170 degree rear-view camera mounted within an aerodynamic fairing on the back of the helmet. The rear-view camera eliminates blind spots behind the rider's head while the aerodynamic fairing reduces lift and reduces wind buffeting noise of the helmet.

**BRIEF DESCRIPTION OF THE DRAWING**

[006] The present invention will be better understood from a reading of the following detailed description, taken in conjunction with the accompanying drawing figures in which like references designate like elements and, in which:

[007] **Fig. 1** is a front perspective view of a helmet incorporating features of the present inventions;

[008] **Fig. 2** is a diagrammatic cross section of the helmet of Fig. 1;

[009] **Fig. 3** is an exploded view of a mounting system for the display of the helmet of Fig. 1;
[010] **Fig. 4** is a representative view from the perspective of a user wearing the helmet of Fig. 1;

[011] **Fig. 5** is a functional block diagram of the electronic modules of the helmet of Fig. 1;

[012] **Fig. 6** is a cross section of the helmet of Fig. 1;

[013] **Fig. 7** is a partial cross section of a portion of Fig. 6 showing details of the rearward-facing camera;

[014] **Fig. 8** is a partial cross section showing details of the forward-facing camera;

[015] **Fig. 9** is a perspective view of the helmet of Fig. 1 with the battery pack removed; and

[016] **Fig. 10** is an enlarged view of a portion of Fig. 6 showing details of the air-powered generator.

**DETAILED DESCRIPTION**

[017] The drawing figures are intended to illustrate the general manner of construction and are not necessarily to scale. In the detailed description and in the drawing figures, specific illustrative examples are shown and herein described in detail. It should be understood, however, that the drawing figures and detailed description are not intended to limit the invention to the particular form disclosed, but are merely illustrative and intended to teach one of ordinary skill how to make and/or use the invention claimed herein and for setting forth the best mode for carrying out the invention.

[018] With reference to the drawing figures and in particular Fig. 1 there is shown a helmet 10 incorporating features of the present invention. Although helmet 10 is depicted as a motorcycle helmet, a helmet incorporating features of the present invention may be implemented
as a bicycle helmet, industrial safety helmet, military or other helmet without departing from the scope of the invention. Helmet 10 is preferably constructed of conventional materials with an inner liner formed of expanded polystyrene or polypropylene foam (EPS) and an outer shell 12 made from a homogeneous plastic such as polyamide, polyethylene or polycarbonate, or from a composite material such as fiberglass, aramid, carbon fiber or other composites.

[019] Helmet 10 includes a conventional face shield 14 and a chin bar 16. Chin bar 16 has a plurality of conventional ventilation intakes 18 which are adjustable to allow a controlled amount of air to enter the helmet for the purpose of reducing fogging of face shield 14 in humid weather and/or for ventilation of the rider. Helmet 10 further includes a plurality of air intakes 20 and a forward-facing camera port 24 the function of which will be discussed more fully hereinafter.

[020] With reference to Figs. 2 and 3, helmet 10 includes a display device 24 mounted to the rear surface 26 of chin bar 16. Display device 24 preferably comprises a virtual image display (VID) unit consisting of a liquid crystal display (LCD), backlight, collimating optics and magnification optics encased in a single device. In the illustrative embodiment, the VID unit comprises a 0.59" WVGA CyberDisplay® display unit manufactured by Kopin Corporation of Westboro, Massachusetts. Display device 24 is attached to chin bar 16 by means of a hinge unit 28, attached to a track engaging member 30. Track engaging member 30 engages a horizontal track 32 having a substantially T-shaped cross section which is rigidly attached to rear surface 26 of chin bar 16.

[021] With additional reference to Fig. 4, track engaging member 30 and track 32 form a sliding mount that enables display device 24 to be moved from the right side position 24A to the left side position 24B of chin bar 16 to accommodate left eye dominant and right eye dominant
users. Track engaging member 30 is locked in place along track 32 using a thumb-wheel cam 34 or similar locking mechanism. The tilt angle of display device 24 may be adjusted by moving the lower surface 36 outward as necessary and locking the display device 24 in place using thumbscrew 38 acting on curved bracket 40. Track engaging member 30, track 32 and cam 34 are preferably made of injection-molded plastic such as polyamide, polyethylene or polycarbonate. Hinge unit 28 may be a conventional strap hinge but is preferably a "live" hinge made of homopolymer polypropylene or other suitable plastic material. As shown in Fig. 2, Display device 24 produces a virtual image 44 which appears to the rider to be behind the chin bar 16 at optical infinity. Because the virtual image 44 appears to be behind (i.e. passing through) the chin bar 16, the virtual image 44 appears in an area that is already obscured from the rider's field of view and therefore does not interfere with or reduce the rider's field of view as with prior art helmets. Optionally the virtual image 44 can be positioned at the top edge of the chin guard.

[022] With additional reference to Fig. 5, helmet 10 includes a helmet control module 50 mounted within the interior of outer shell 12. Helmet Control Module (HCM) 50 comprises a System on Chip (SoC) integrated circuit 52 for managing the video and audio I/O, Wi-Fi connection, power management and other functions. HCM 50 may also include a digital output gyroscope/accelerometer 54 the purpose of which is discussed more fully hereinafter. HCM 50 receives video information via a Wi-Fi link 62 which HCM 50 then converts into the appropriate video format for display on display device 24. Although in the illustrative embodiment HCM 50 receives information via Wi-Fi link 62 the invention is not limited to Wi-Fi wireless link. Other wireless communication protocols such as Bluetooth® or other wireless protocols now existing or hereafter developed may be used within the scope of the invention. HCM 50 similarly
processes audio information received via Wi-Fi link 62 which is then amplified and played through headset 56 housed within helmet 10. HCM 50 similarly processes voice commands, which may be received via microphone 58 embedded in or otherwise attached to helmet 10. In the illustrative embodiment, System on Chip IC 52 comprises a Broadcom BCM 2835, Wi-Fi link 62 comprises a Texas Instruments CC3000, the display driver comprises an Intersil TW8835 and the audio amplifier comprises a Maxim MAX98090.

[023] As noted hereinbefore, HCM 50 includes a gyroscope/accelerometer 54 the purpose of which is twofold. Gyroscope/accelerometer 54 may be used to track the head movements of the rider in order to operate a main or auxiliary headlamp that moves in sync with the rider's head rather than with the front wheel. Additionally, however, gyroscope/accelerometer 54 may be used to provide input to an algorithm that automatically contacts emergency responders in the event of a sudden deceleration (indicative of a possible collision) followed by an absence of movement and/or absence of vocal command. To avoid false positive detection of a collision, an additional sensor such as a proximity sensor and/or thermal sensor is incorporated to determine if the helmet is being worn, or has simply been removed and thrown onto the ground or otherwise discarded. In the illustrative embodiment, gyroscope/accelerometer 54 comprises a Maxim MAX21000 3-D rate sensor.

[024] With additional reference to Figs. 6-8, helmet 10 is equipped with a rear facing camera 60, preferably having a 150°-200°, preferably approximately 170° field of view. As is known in the art, it is common to equip motorcycle helmets with the rear spoilers in order to reduce lift and/or wind buffeting of the helmet and associated noise at high speed. In the illustrative embodiment, rear-facing camera 60 is mounted within rear spoiler 64 of outer shell 12 thereby utilizing what would otherwise be wasted space. The image from rear-facing camera
60 is processed by HCM 50 and displayed on VID 24 thereby providing the rider with a rear view image, obviating the necessity of the rider to turn his/her head in order to view oncoming traffic. Optionally, rear facing camera 60 may be gyroscopically stabilized using the output from gyroscope/accelerometer 54. An additional chin spoiler 100, preferably formed of a soft polymer material may be attached to chin guard 16 to further reduce wind noise and lift at high speeds. Optionally, chin spoiler 100 may include a microphone and/or additional electronics for operating VID 24 and is removably attached with magnets (e.g. with neodymium or other rare earth permanent magnets) which also act as signal transmitters between chin spoiler 100 and helmet 10).

Macroscopic adjustments of rear-facing camera 60 may be affected by moving lens port 66 upwards and downwards within corresponding apertures 68 and 70 formed in the outer shell 12. Movement of lens port 66 enables rear-facing camera 60 to pivot about a pivot 72. Appropriate seals 74 disposed between lens port 66 and apertures 68, 70 are provided for weatherproofing. Helmet 10 may optionally be equipped with a forward-facing camera 76. The mounting and adjustment of forward-facing camera 76 is identical to the mounting and adjustment of rear-facing camera 60 and therefore will not be discussed in detail herein. Coaxial infrared light emitting diodes 78 are also included to improve visibility in low-light conditions. In the illustrative embodiment rear-facing camera 60 and optional forward-facing camera 76 each comprises an OV7670 Robot Camera Module manufactured by Shenzhen Shanhai Technology Ltd. of Guangdong, China. Additional sensors, such as scanning LIDAR and radar are used to extend the rider's visual range during night or impaired weather conditions. These sensors are also used to detect objects under all atmospheric conditions so as to warn the rider of a possible impact. The warning may consist of an image displayed on VID 24, a visual warning
symbol, as well as an audio signal. The rider will have the option to add full or partial automatic brake control to assist in impact prevention.

[026] The power requirements of HCM 50 and the other components embedded in helmet 10 necessitates use of a relatively high-capacity battery pack to provide reasonable service life between charges. With additional reference to Fig. 9, in order to minimize the adverse effects of mounting a heavy, high-capacity battery pack, helmet 10 incorporates a battery pack 80 comprising a body having a substantially arcuate profile within inside radius R1 of approximately 65 millimeters and an outside radius R2 of approximately 92 millimeters and a height H of approximately 75 millimeters. The shape of battery pack 80 allows it to fit low and close around the base of the rider's neck extending substantially from ear-to-ear, while the outer surface conforms to the helmet outline. By positioning battery pack 80 low and close around the base of the rider's neck, the moment of inertia of battery pack 80 is minimized relative to the normal turning and tilting motion of the rider's head. Battery pack 80 is replaceable using conventional plug-in connectors and releasable catches. Optionally, helmet 10 includes a barrier wall formed as part of outer shell 12 to isolate battery pack 80 from the rider wearing helmet 10.

[027] With reference to Figs. 6 and 10, helmet 10 is equipped with an internal air passageway 82 which leads from air intake 20 to exhaust port 84. Ram-air entering air intake 20 passes through an air-powered electrical generator such as air turbine/generator assembly 86 housed within air passageway 82. Electricity generated by air turbine/generator assembly 86 is used to augment the power supplied by battery pack 80, thereby extending battery life. A portion of the ram-air passing through the air turbine/generator assembly 86 may also be directed to a series of cooling ports 88 to cool the rider's head in warm weather. The remaining portion of the ram-air passing through the air turbine/generator assembly 86 exits exhaust port 84 which is
connected to air inlet 90 of battery pack 80. Air entering air inlet 90 is directed through a series of cooling channels 92 formed in battery pack 80 to cool the batteries within battery pack 80 ultimately exiting battery pack 80 via battery pack exhaust port 92. In warm weather and slow speeds, air turbine/generator assembly 86 can be electrically reversed to operate as a circulating fan to cool the rider's head by drawing air through air intake 20 and discharging it through cooling ports 88. A thermal sensor may be incorporated into the helmet to determine when the fan should be switched on to cool the helmet interior.

[028] With reference again to Fig. 5, a main control module (MCM) 100 is a System on Chip integrated circuit provided to control certain functions associated with helmet 10. MCM 100 includes a smartphone link 102 (iOS, Android or other smartphone operating system) to provide GPS navigation, voice and data communication and other functions associated with a smartphone 104. MCM 100 also includes the input output control 106 receiving signals from the manual control interface 108. In the illustrative embodiment, although most commands are contemplated to be voice commands via microphone 58, a manual control interface such as a joy-button or other physically manipulated switch array may be provided as appropriate. MCM 100 further includes a light sensor control 110 which receives signal from an ambient light sensor 112. Light sensor control 110 adjusts the light output of VID 24, determines when infrared LEDs 78 are necessary and performs other functions as necessary based on the ambient light conditions. Light sensor control 110 may also be used to adjust the darkness of face shield 14 to control the ambient light within the helmet. Alternatively face shield 24 itself may have an auto-dark function. MCM 100 also includes a wireless or wired interface with the vehicle engine management system to receive vehicle speed, engine oil pressure, engine temperature, fuel reserve, fuel economy and other vehicle metrics. In the illustrative embodiment, the System on
Chip IC comprises a Broadcomm BCM 2835, the smart phone link comprises a USB to iOS (iPhone) cable and the ambient light sensor comprises a Maxim MAX44009 light sensor.

Although certain illustrative embodiments and methods have been disclosed herein, it will be apparent from the foregoing disclosure to those skilled in the art that variations and modifications of such embodiments and methods may be made without departing from the invention. For example, although in the illustrative embodiment display device 24 is not a heads-up-display, use of a heads-up display in combination with the other features of the present invention is considered within the scope of the invention. Additionally, although voice commands and/or manual switches are shown in the illustrative embodiment, simple thought commands (e.g. yes/no) detected by EEG are within the scope of the invention as are blink detection commands using an optical eye or eyelid detector. Additional programming functionality may include lockouts that prevent manual input under certain conditions, e.g. speed above a particular threshold, so as to avoid an unsafe condition. Accordingly, it is intended that the invention should be limited only to the extent required by the appended claims and the rules and principles of applicable law. Additionally, as used herein, references to direction such as "up" or "down" are intend to be exemplary and are not considered as limiting the invention and, unless otherwise specifically defined, the terms "generally," "substantially," or "approximately" when used with mathematical concepts or measurements mean within ± 10 degrees of angle or within 10 percent of the measurement, whichever is greater.
What is claimed is:

1. A helmet system for displaying information to a user comprising:
   an helmet outer shell;
   a substantially transparent face shield attached to the helmet outer shell;
   a chin bar disposed below the face shield, the chin bar having an outside surface facing away from the user and an inside surface facing toward the user;
   a virtual image display mounted to the inside surface of the chin bar, said virtual image display adapted to display information to the user including navigational information, vehicle metric information and/or rear view image information, the virtual image display projecting information to the user as a virtual image passing through the chin bar, whereby the virtual image does not substantially reduce the user's field of view through the face shield.

2. The helmet system of claim 1, further comprising:
   a horizontal track mounted to the inside surface of the chin bar;
   a track engaging member slingly engaging the horizontal track, the virtual image display being mounted to the track engaging member, whereby the virtual image display may be positioned by the user along the horizontal track to a left-eye dominant position to a right-eye dominant position.

3. The helmet system of claim 2, further comprising:
   a horizontal hinge member disposed between the virtual image display and the track engaging member, whereby the virtual image display may be tilted upwards or downwards to suit an individual user.
4. The helmet system of claim 4, wherein:
   the virtual image display is moveable vertically.

5. The helmet system of claim 4, further comprising:
   a main control module carried outside the helmet outer shell, the main control module
   comprising an integrated circuit providing a smart phone data interface, a manual control
   interface and a wireless data link, the main control module being powered from a vehicle power
   system;
   a helmet control module mounted within the helmet outer shell, the helmet control
   module comprising an integrated circuit providing a wireless data link for communicating with
   the main control module and a video controller processing information for display on said virtual
   image display, the helmet control module being powered from a battery pack;

6. The helmet system of claim 5, wherein;
   the battery pack comprises a body having an arcuate profile conforming to a lower region
   of the helmet outer shell.

7. The helmet system of claim 6, wherein;
   said battery pack is attached to the helmet outer shell in a region proximal the base of the
   user's neck extending substantially from ear-to-ear.

8. The helmet system of claim 7, further comprising:
   a first video camera mounted to the rear portion of the helmet outer shell.
9. The helmet system of claim 8, wherein:
   the helmet outer shell is formed with an aerodynamic spoiler located on the rear surface thereof, the spoiler also acting as a housing to surround and protect the first video camera.

10. The helmet system of claim 9, wherein:
    the first video camera is mounted to pivot about a horizontal pivot attached to the helmet;
    the spoiler is formed with a rearward-facing aperture having a vertically sliding lens port disposed therein; and
    the first video camera is mounted with the lens of the camera extending through the lens port, whereby the camera may be adjusted by sliding the lens port vertically so that the first video camera rotates about the horizontal pivot.

11. The helmet system of claim 5, further comprising:
    an air passageway inside the helmet outer shell, the air passageway having an intake port at a forward-facing surface of the helmet outer shell and an exhaust port facing inward toward the user, whereby ventilation may be provided to the user.

12. The helmet system of claim 11, wherein:
    the battery pack has an interior passageway for cooling ventilation, the battery pack internal passageway having an inlet; and
    the air passageway has an exhaust port cooperating with the battery pack internal passageway to provide cooling ventilation to the interior of the battery pack.
13. The helmet system of claim 11, further comprising
   an air-powered generator disposed in the air passageway, the air-powered generator
   providing power to augment the battery pack

14. The helmet system of claim 13, wherein:
   the air-powered generator is reversible so that it is operated as a battery-powered fan to
   provide a cooling airflow to the user.
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. A42B3/04 A42B3/28 A42B3/30

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

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

A42B G02B

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

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

EPO-Internal , WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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<td>col umn 8, line 6 - col umn 7, line 58; figures 1,5,6,35; col umn 19, lines 31-64</td>
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*Further documents are listed in the continuation of Box C.*

See patent family annex.

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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

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

2 August 2013

Date of mailing of the international search report

09/08/2013

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL 2280 HV Rijswijk
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Authorized officer

D'Souza, Jennifer
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