WEARABLE APPARATUS, METHOD, CONTROLLER AND AIRBAG THEREOF

TECHNICAL FIELD

The present invention relates to a wearable apparatus, a controller for the wearable apparatus, a method of operating a wearable apparatus and an airbag coupled to the wearable apparatus. In particular, the present invention relates to a wearable apparatus, a controller and an airbag configured to reduce injury to a human body in case of accident.

BACKGROUND

Safety devices such as airbags are equipped in motorized vehicles as a protection means for the driver and passengers of the vehicle in case of accidents. The efficacy of these safety devices is limited according to the placement of these devices within the vehicle and the method of deployment of such devices. In some circumstances, it may be impractical to equip motorized vehicles with safety devices of same type due to the fact that motorcyclists are riding in an open environment and the complexity of the accident situations of motorcycles.

SUMMARY OF INVENTION

A wearable apparatus includes a helmet and an airbag attached to a bottom rim of the helmet. In the event of an accident, for example when ta motorcyclist riding a motorcycle collides with an object, the airbag is triggered by the accident event and activated to inflate surrounding the lower rim of the helmet, to form a cushion surrounding the neck portion of the motorcyclist. The airbag is inflated within a very short time e.g. 10 several tenths of a second, before the motorcyclists is thrown off the motorcycle and hit a surrounding object that may cause injury to the motorcyclist. The inflated airbag therefore form a protection to the neck portion of the motorcyclist, to greatly reduce the level of injury.

In one embodiment, a wearable apparatus comprises a base; a control unit mounted to the base; a folded airbag mounted to the base; and an ignitor disposed in the folded airbag and coupled to the control unit. The control unit is configured to detect an impact signal of the base and upon the impact signal reaching a predetermined threshold, the control unit activates the ignitor to inflate the folded airbag.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention are disclosed hereinafter with reference to the drawings, in which:

Fig. 1 is a schematic view showing a riding and accident situation that a motorcyclist encountered;

Fig. 2 is a perspective top view of a wearable apparatus according to one embodiment of the present invention;

Fig. 3 is a perspective bottom view of a wearable safety device of Fig. 2;

Fig.4 is a cross-sectional perspective view of Fig. 2;

Fig. 5 is a perspective view showing the wearable apparatus of Fig. 2 when the airbag is inflated;

Fig. 6 is a schematic diagram and an x-y-z coordinate system showing the terms used in line with the acceleration and inertia data acquired by the wearable apparatus of Fig. 2;

Fig. 7 is a schematic diagram showing an x-y-z coordinate system referred to in the context with respect to a motorcyclist;

Fig. 8 is a block diagram showing a safety assembly for use in the wearable apparatus of Fig. 2.

Fig. 9 is a perspective view of a wearable apparatus according to another embodiment;

Fig. 10 shows the apparatus of Fig. 9 upon inflation of the airbag;

Fig. 11 is a cross sectional view of Fig. 9 along A-A;

Fig. 12 is an enlarged view of portion 11a of Fig. 11;

Fig. 13 is an enlarged view of portion 11b of Fig. 11;

Fig. 14 is an exploded view of Fig. 9;

Fig. 15 is a perspective view showing the folded airbag of the apparatus shown in Fig. 8;

Fig. 16 is an exploded view of Fig. 10;

Fig. 17A, 17B and 18 show a wearable apparatus according to a further embodiment;

Fig. 19 is a flowchart showing an operation process of a wearable apparatus.

Fig. 20A is a front view showing individual pieces of an airbag at the inflated state;

Fig. 20B is a top view of Fig. 20A;

Fig. 20C is a perspective view of Fig. 20A;

Fig. 20D is a perspective view of Fig. 20A viewing from another angle;

Fig. 20E is an exploded view of Fig. 20;

Fig. 21 shows the airbag chamber and the folded airbag disposed in the chamber;

Fig. 22A shows a positional relationship between the lower rim (an approximately elliptical shape) of a full face helmet, a user's neck and an airbag, before and after inflation.

Fig. 22B shows the airbag of Fig. 22A folded along a longitudinal direction;

Fig. 23A shows an airbag attached to a full face helmet and before inflation;

Fig. 23B shows the airbag of Fig. 23A after inflation;

Figs. 24A, 24B and 24C show the inflation process of the airbag shown in Fig. 23A;

Fig. 25A shows a positional relationship between the lower rim (an approximately elliptical shape) of a semi face helmet, a user's neck and an airbag, before and after inflation.

Fig. 25B shows the airbag of Fig. 25A folded along a longitudinal direction;

Fig. 26A shows an airbag attached to a semi face helmet and before inflation;

Fig. 26B shows the airbag of Fig. 26A after inflation;

Figs. 27A, 27B, 27C and 27D show the inflation process of the airbag shown in Fig. 26A.

Fig. 28 to Fig. 31 are schematic diagrams showing a fabrication method of an airbag for using with a helmet according to another embodiment of the present invention.

Fig. 32 is a flow chart showing a method of forming an air bag according to one embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

As shown in the Figs. 1 to 5, a wearable apparatus 100 is provided to a motorcyclist 10 for use while riding a motorcycle 20. According to one embodiment of the present invention, wearable apparatus 100 includes a helmet 110 and a folded airbag 120 attached to a bottom rim 112 of the helmet 110. In the event of an accident, for example when the motorcyclist 10 riding the motorcycle 20 collides with an object 30, the folded airbag 120 is triggered by the accident event and activated to inflate surrounding the lower rim 112 of the helmet 110, to form an inflated airbag 120' surrounding the neck portion of the motorcyclist 10. The airbag 120 is inflated within a very short time upon occurrence of an accident, e.g. within several tenths of a second, before the motorcyclist 10 is thrown off the motorcycle 20. Inflated airbag 120' is shaped and dimensioned to surround the neck portion 12 of the motorcyclist 10. The inflated airbag 120' therefore forms a means of protection to the neck portion of the motorcyclist 10, to greatly reduce the level of injury.

Wearable apparatus 100 comprises an accelerometer 130, a controller 140, an ignitor / inflator 150 and a power source 160 fixed to helmet 110. Power source 160 may be one that is used in the motorcycle and supplied via a power supply cable, or a separate battery unit assembled into the helmet 110, which maybe an alkaline battery, a

rechargeable battery, a solar battery, etc. Wearable apparatus 100 may further include a communication module such as a GPS module to wirelessly connect to a backend, for example a traffic control center 190, via cloud 50.

Helmet 110 has a rigid external shell 122 made of structurally strong material such as carbon fiber, polyethylene terephthalate or fiber-reinforced plastic or the like, etc., and a lining 124 made of soft material e.g. fabric or plastic foam inside the external shell. The accelerometer 130, controller 140, ignitor / inflator 150, battery 160 and GPS module 180 of the wearable safety device 100 may be fixed to the helmet 110 between the external shell 122 and lining 124, and electrically connected by cables 170. When the helmet 110 is worn by a user e.g. a motorcyclist and used during riding, the accelerator 130 detects the movement status of the motorcyclist by measuring the acceleration and/or speed of the helmet 110 to which the accelerator 130 is fixed, and transmits the measurement results to the controller 140 for processing and determination.

Accelerometer 130 is electrically connected to controller 140 via cable 170 which can be imbedded into the space between the external shell 122 and the lining 124 of the helmet 110. Accelerometer 130, controller 140, ignitor 150, battery 160 and GPS module 180 are electrically connected via cables 170. Ignitor 150 is connected to airbag 120 via tube 172. Cables 170 and tube 172 can be imbedded into the space between the external shell 122 and lining 124 of the helmet 110.

Accelerometer 130 detects the movement status of the motorcyclist wearing the helmet 110, while the motorcyclist riding a motorcycle. The movement status may be determined by one or more data e.g. linear acceleration / speed, angular acceleration / speed that can be detected and measured by the accelerometer 130.

In an event of accident, the motorcyclist's movement status is suddenly changed as compared to the normal riding situation. Such changes / impact are captured by the accelerometer as acceleration data, and processed by the controller to derive a Movement Index. The Movement Index is compared with a pre-determined threshold value. Upon the Movement Index exceeds the threshold value, the controller 140 determines the

occurrence of an accident, and triggers the ignitor / inflator that in turn releases a fluid into tube 172 and inflates the folded airbag 120.

The accident situation may be further verified prior to the controller 140 triggering the ignitor / inflator 150, by making use of the speed data. For example, the controller 140 may be configured to trigger the ignitor / inflator 150 upon the average speed in a certain time period (e.g. 2 seconds) prior to the accident exceeds a predetermined speed limit. Making use of the speed data has the advantage of preventing fault triggering of the ignitor / inflator 150 in situations where the wearable apparatus is not in actual use.

In one embodiment, the Movement Index includes a Collision Index that is defined and derived based on the linear and/or angular acceleration / speed measured by the accelerometer 130, before and after the accident. The measurement results are transmitted to and processed by the controller 140.

In one embodiment, as illustrated herein in conjunction with Figs. 6 and 7, the accelerometer 130 is a 3-dimensional motion sensor capable of detecting the 3-dimensional (X-Y-Z directions) linear acceleration a_x (t), a_y (t) and a_z (t), and 3-dimensional angular acceleration α_x(t), α_y(t) and α_z (t), at predetermined time intervals. The controller 140 receives the measurement data from the accelerometer 130 and processes calculations to derive the Collision Index based on the linear acceleration in X, Y and Z directions, angular acceleration in X, Y and Z directions, critical linear acceleration in X, Y and Z directions and critical angular accelerations in X, Y and Z directions.

The accelerometer 130 maybe positioned within or on top of the helmet along the z-axis as defined by the longitudinal axis of the neck of motor cyclist (as shown in Fig. 7) in an upright position, and as far away from the neck as possible so that the accelerometer is most sensitive to motion of the motorcyclist's head about the neck.

According to another embodiment, a wearable safety device 100 includes an inertia sensor 132 affixed to the helmet 110, and coupled to the controller 140. Independent from

the accelerometer 130, inertia sensor 132 is a 3-axis linear pressure sensor capable of measuring the X-Y-Z axes inertia data of the motorcyclist 10 during riding and in case of any accident, measurements result of the inertia sensor 132 is transmitted to the controller 140 for processing.

In another embodiment, the Movement Index may include an Injury Index that is defined and derived based on tensile and/or compression force along longitudinal direction of the neck spiral, the bending moment applied to the upper neck portion in X direction and Y directions, the critical force bearing capacity and critical moment bearing capacity in X direction and Y directions.

In a preferred embodiment, the Movement Index comprises both the Collision Index and Injury Index.

Fig. 8 is a block diagram showing the controller 140 for use in a wearable apparatus 100 of Fig. 2 and connections with other components. Controller 140 may be in the form of an integrated device including a Collision Index calculator 141 and an Injury Index calculator 142 connected to the accelerometer 130 and inertia sensor 132, to acquire and process the acceleration data and the inertia data. A bios module 143, a memory module e.g. RAM 144 and a logic module 145 are coupled to the Collision Index calculator 141 and the Injury Index calculator 142 to store the calculation results and determine criteria for triggering the ignitor / inflator 150 to activate the air bag 120. GPS module 180, in the form of either a standalone component or integrated in the accelerometer 130, is coupled to the controller for transmitting the motorcyclist's physical location information to a back end for tracking and further data analysis.

Wearable apparatus 100 may further include a communication port 182 such as USB port coupled to the controller 140, for charging the battery 160 and/or retrieving data from the controller 140 for analysis. Additionally, wearable apparatus 100 may include a test port 184 to verify that the parts and modules are under normal working condition each time before the device 100 is used. Wearable apparatus 100 may further include a switch

to control the operation of device 100 and indicator lights to indicate the operation state of device 100. Solar panel may be included to power the wearable apparatus 100.

In yet another embodiment, as shown in Figs. 9 to 16, a wearable apparatus 200 includes a base such as a helmet 210, a control unit 202 mounted to the helmet 210, a folded airbag 220 mounted to the helmet 210, and an ignitor 250 disposed in the folded airbag 220. The control unit 202 is configured to detect an impact signal of the helmet 210 and upon the impact signal reaching a predetermined threshold, the control unit 202 activates the ignitor 250 to inflate the folded airbag 220.

The helmet 210 has a rigid shell 210a, and the folded airbag 220 is mounted to a bottom rim 212 (Fig. 13) of the shell 210a. The Wearable apparatus 200 may include a holder 206 in which the folded airbag 220 is disposed. The holder 206 is detachably mounted to the bottom rim 212 of the shell 210a. Upon the folded airbag 220 being inflated, the holder 206 is detached from the helmet 210 such that the inflated airbag 220' remains attached to and support the neck portion of a user, to provide protection support to the user to reduce the risk of injury to the neck portion.

The control unit 202 is mounted to an external top surface of the rigid shell 210a and having an electrical cable 204 imbedded in the shell 210a to electrically coupling the control unit 202 and the ignitor 250.

The ignitor 250 maybe detachably coupled to the cable 204 and upon inflation of the folded airbag 220, the ignitor 250 is detached from the cable 204, such that the cable 204 and the control unit 202 are prevented from causing possible injury to the user.

The folded airbag 220 maybe formed of an open loop (Figs. 14, 15) to better fit the neck portion of a human body. The folded airbag 220 has a first end 220a and a second end 220b disposed adjacent to each other, the wearable apparatus 200 further comprises a first fastening member, e.g. a first belt 228a mounted to the first end 220a and a second fastening member e.g. a second belt 228b mounted to the second end 220b and lockable to the first belt 228a, to prevent the first and the second ends 220a, 220b from separating

away from each other which may result in failure protection by the inflated airbag 220' to the user's neck portion.

The control unit 202 includes an accelerometer 230 for detecting the impact signal of the helmet 220, which corresponds to the movement status of a user riding a motorcycle, a processor 240 coupled to the accelerometer 230 for determining the impact signal with respect to the predetermined threshold.

The wearable apparatus may include a housing 201 into which the control unit 202, the accelerometer 230, the processor 240 and other components such as battery 260, GPS module 280 are disposed. The housing 201 may be mounted to the helmet 210 in a detachable manner, by screw for example, or a non-detachable matter by e.g. an adhesive.

The folded airbag 220 is shaped and dimensioned to conform to a body part of a user wearing the apparatus upon inflation.

The wearable apparatus 200 may include a one-way safety valve 292 mounted on the folded airbag 220. In the event that the air pressure of the inflated airbag 220' exceeds a predetermined pressure limit, the one-way safety valve 292 is opened to release the air pressure. An advantage of having a one-way safety valve 292 is to prevent the likelihood of reduction of protection by an over-pressured inflated airbag 220'.

While the invention has been described in the preceding paragraphs in the form of a safety helmet, it should not be interpreted as limiting to the scope of the current invention. For instance, the wearable apparatus may assume the forms of other headwear or apparel like a vest for use by workers to mitigate the risk of e.g. falling from heights. The airbag may be inflated in response to a falling motion and aids in lessening the impact of the fall to vital organs of the wearer.

Figs. 17A, 17B and 18 show an embodiment of a wearable apparatus 300 in the form of a vest 301. Vest 301 may comprise a zip 303 that is secured at the top end by a button 302 to facilitate wearing and removal of the vest 301. A module housing 390 may

take the form of a belt and houses a controller 340, accelerometer 330, battery 360, a plurality of ignitors 350 electrically connected to the controller 340 by cables 370. A plurality of folded airbags 320 that may be inflated by the plurality of ignitors 150 are positioned at the collar, front and back of the vest 301. The wearable apparatus 300 functions similarly to the wearable apparatus 100. The controller 340 measures and transmits acceleration/speed data acquired from the accelerometer 330 for deriving a Movement Index. In the event of a wearer falling from certain height, if the Movement Index exceeds a pre-determined threshold, the controller 340 triggers the ignitors 350 which in turn inflate the folded airbags 320 as shown in Fig. 18. The inflated airbags 320' surround a wearer's neck and also form protective cushions on the front and back of the wearer to reduce the impact from the fall.

The predetermined threshold may be determined based on whether the acceleration in vertical direction is equal to or greater than one time of the gravitational acceleration (1g), and whether the falling height is greater than a limit that may cause injury to a human body under typical situations, e.g. 2 meters. It is therefore understandable that by adopting the predetermined threshold based on criteria dedicated to a particular application, a wearable apparatus can be configured to be suitable for use in such application.

The wearable apparatus 300 may further comprise an altimeter 380 for measuring the height of the apparatus relative to a ground surface, to provide additional information for the determination of the threshold and provide efficient and reliable effect of triggering the airbags in case of need.

In another aspect of the invention, a method 900 of operating a wearable apparatus is shown in Fig. 19. The method starts with a self-test at block 902. In the event that an error is detected at block 904, for example a part / component failure, insufficient battery voltage, etc, the selftest will fail and an alarm is triggered at block 906 to prompt the user to remedy the problem/error. If the selftest is successful, the apparatus will start acceleration/inertia data acquisition at block 908, to obtain and accumulate the acceleration / inertia data of the device. Thereafter, the apparatus determines, at block

910, based on the acceleration / inertia signal acquired, whether a Collision Index exceeds a predetermined threshold. If not, the process loops back to block 908 to continue the acceleration / inertia data acquisition for next determining cycle. If the Collision Index exceeds the threshold, the apparatus determines that an abnormal event takes place, for example an accident happened, and proceed to block 914 to activate the ignitor to inflate the airbag.

Parallel to the Collision Index determination, the apparatus determines at block 912, based on the acceleration / inertia date/signal acquired, whether the Injury Index exceeds a predetermined threshold. If not, the process loops back to block 908 to continue the acceleration / inertia data acquisition for next determining cycle. If the Injury Index exceeds the threshold, the device determines that an abnormal event takes place, for example an accident happened, and proceed to further checking at block 413 whether the speed of the wearable apparatus exceeds a predetermined limit. If so, the method proceeds to block 914 to activate the ignitor to inflate the airbag. If not, the method looks back to block 908 to continue the acceleration / inertia data acquisition for next determining cycle.

According to another embodiment, the present invention provides an airbag for coupling to a wearable apparatus. As shown in Figs. 20A to 27D, The airbag is made of pliable, collapseable and air-tight material such as polymer, nylon or the like. Upon fully inflated, the airbag may have a cross-sectional diameter of about 10 to 15 cm, suitable for providing appropriate support and protection to the neck portion of a user, without over-pressing the mandibular portion of the user. At the fully-inflated state, the airbag expands to a generally torus shape, with an inner diameter D11 slightly greater than the neck portion of a user, such that the space between the inner edge of the inflated airbag and the neck portion is not too excessive to loosen the support to the neck portion. The outer diameter D12 may be dimensioned by taking into consideration collectively the cross-sectional dimension and the volume of the airbag, as well as the perimeter of the lower rim of a helmet to which the airbag is to be attached.

The airbag may be made by stitching or hot-pressing individual pieces into an integral part. In one embodiment as show in Figs. 20A, 20B, 20C, 20D and 20E, airbag

400 is formed by six individual pieces 401, 402, 403, 404, 405 and 406 stitched together, in which individual pieces 401 and 402 are open-ended ring shape, individual pieces 403 and 404 are ribbon-shaped. The width of the individual pieces is about 1/4 of the perimeter of the inflated airbag along the transversal direction, such that the folded portions of each individual piece can be evenly arranged to ease assembly. The end openings of the airbag are closed by individual pieces 405 and 406. The edges of the closed openings may be chamfered or filleted to smoothen the external surface of the airbag, to reduce the possibility of causing injury to the neck portion when the airbag is inflated. The open ends of the airbag is positioned underneath the mandibular portion of the user. The air inlet of the airbag is positioned right at the back side of the neck.

Fig. 21 shows the folded state of the airbag along transverse/radial direction. The portion outside of the non-folded region are formed with multiple folds and is orthogonal to a non-folded plane. The height of the folded airbag is less than the internal clearance of the airbag chamber. The remaining portion of the clearance of the airbag chamber is reserved for subsequent folds of the airbag along longitudinal / annular direction.

The airbag has a fastening belt attached to the end portions. When the airbag is fully inflated, the fastening belt serves to hold and tighten the end portions to each other such that the inflated airbag firmly grips the neck portion of a wearer to provide the necessary protection to the neck portion of the wearer. The fastening belt is fixed to the end portions of the airbag. The length is configured to tighten the two ends of the airbag upon inflation. The fastening belt may be made of nylon cable tie.

Detachable airbag housing

Fig. 21 shows a cross section of a detachable airbag casing 2110. The detachable airbag casing 2110 may be made of elastic rubber by injection molding. The detachable airbag casing 2110 includes a first housing 2112 fixed to the lower rim of a helmet, and a second housing 2114 detachably coupled to the first housing 2112. The first housing has a dovetail groove formed thereon. The second housing has a generally U-shaped cross section, with flanges formed on an upper rim of the second housing and an opening

between the flanges. The second housing may be generally strip-shaped and is resiliently deformed into a ring shape with two ends facing each other and located at a back side of the neck. Upon the flanged being fitted into the dovetail groove, the second housing is tightly engaged to the first housing to form the airbag chamber.

Operation of the airbag

As shown in Fig. 21, the first housing is fixed to the lower rim of a helmet 2102, with the dovetail groove facing downward of the helmet. The airbag has an air inlet positioned right at the back portion of the helmet, and the air is supplied to the airbag along a direction from the upper portion of the airbag toward the power portion of the airbag. Upon receipt of a pressurized air, the airbag is inflated from the upper portion toward the lower portion. In the meantime, the inflated airbag exerts a pressure from the inner side of the airbag chamber to expand the second housing. Upon the airbag being inflated under the air pressure to a volume greater than the holding capacity of the airbag chamber, the airbag will cause the flange of the second housing to be disengaged from the dovetail groove to disengage the second housing from the first housing. The second housing is positioned at the back portion of the neck of a user, and is progressively disengaged from the first housing starting from the ends of the second housing, following the inflation process of the airbag.

Full face helmet

Airbag assembly along longitudinal/annular direction

The positional relationship of a user's neck, the helmet and the airbag

Fig. 22A shows a positional relationship between the lower rim (an approximately elliptical shape) of a full face helmet 2202, a user's neck and an airbag 2220, before and after inflation. As shown, after inflated, the portion near the airbag adjacent to the back portion of the neck expands outwardly, while the other portions of the airbag remain the same position before and after inflation.

Airbag assembling method

As shown in Fig. 22B, according to the positional relationship illustrated above, the airbag is folded along the longitudinal/annular direction in the following manner:

Configure the overall length of the airbag inner diameter, the two ends of the opening, and a small portion of the outer diameter adjacent to the opening to be the same as the perimeter of the lower rim of a helmet, straightening the airbag and imbedding the airbag into the airbag chamber along the inner side. The remaining portion of the airbag (the length of which is greater than 20% of the perimeter of lower rim of the helmet) is folded along longitudinal / annular direction. The portion in front half of the neck portion is folded with low density, while the other half at the back portion of the neck has a relatively high density, and is imbed into the airbag chamber and adjacent to the outer sidewall of the airbag.

Fastening belts for tightening the opening ends of the airbag

As shown in Fig. 22B, the fastening belts are positioned at the inner portion under the lower rim of the helmet, attached to the outer surface of the airbag and has a length spanning the distance between the opening ends of the airbag. The fastening belts may be unfolded before and after the airbag inflation.

The inflation process of the airbag along the longitudinal /annular direction

Figs. 23A and 23B show the shapes of the airbag before and after inflation. Figs. 24A, 24B and 24C show the airbag shapes before, during and after inflation, and the detachment process of the airbag chamber.

Semi-face helmet

Assembly of the airbag along longitudinal / annular direction

Positional relationship of a user's neck, the helmet and the airbag

Fig. 25A shows a positional relationship between the lower rim (an approximately horseshoe shape) of a semi face helmet. Similar to the full face helmet, after inflated, the portion near the airbag adjacent to the back portion of the neck expands outwardly, while the other portions of the airbag remains the same position before and after inflation. The difference lies in the lower rim of semi face helmet which has a shape different from that of the full face helmet.

Airbag assembling method

As shown in Fig. 25B, as the lower rim of a semi face helmet is significantly shorter than the lower rim of a full face helmet, the airbag is folded along longitudinal/annular direction in the following manner:

Configuring the overall length of the inner diameter, the two ends of the opening and part of the outer diameter adjacent to the opening to be the same as the remaining portion of the outer diameter of the airbag, folded at the middle of the configured length and inserted into the airbag chamber with same folding density. It is estimated that after folded along the longitudinal / annular direction, the overall length is shortened by about 23%.

Airbag tightening strap

As shown in Fig. 25B, the chin strap is positioned at the inner portion under the lower rim of the helmet, attached to the outer surface of the airbag and has a length spanning the distance between the opening ends of the airbag.

Before the airbag is inflated, the chin strap is exposed to the outside of the airbag chamber. The chin strap has a fastening element to tighten the strap at the mandibular portion of the user, to keep the helmet in close contact with the user's head. During the

inflation process, the inflated airbag expands to stretch the chin strap to move the fastening element along the strap, such that the strap tightly retains the opening ends of the inflated airbag.

The inflation process of the airbag along the longitudinal direction

Figs. 26A and 26B show the shapes of the airbag before and after inflation. Figs 27A, 27B, 27C and 27D show the airbag shapes before, during and after inflation, and the detachment process of the airbag chamber. The two front ends of the airbag move forward during the process of airbag inflation.

According to another embodiment, as shown in Fig. 28, an airbag 800 is made of a thin sheet of pliable fabric material such as nylon, polyester or the like. At a fully inflated state, the airbag 800 forms a bent or curved sleeve having an outer rim 801, an inner rim 809 of a length approximately the same or slightly greater than a perimeter of a neck portion of a wearer e.g. an adult human being, a sleeve tube 803 having a tube diameter D3, a first end 802, a second end 808 and a gap 805 between the first end 802 and the second end 808.

In a fabrication process, as shown in Fig. 29 to Fig. 31, a thin and pliable flat sheet 810 is provided, that is a generally rectangle-shaped fabric having a pair of long sides 812, 818 with a sheet length 810L and a pair of short sides 822, 828 with a sheet width 810W. Flat sheet 810 may be made of nylon, polyester or similar type of fabric that satisfies necessary operational requirements of an air bag, i.e. pliable and collapsible before use, and expandable and capable of holding pressurised air therein for a predetermined period of time. The sheet length 810L has a dimension about the same as the length of the outer rim 801 of the air bag 800 at the inflated state. The sheet width 810W has a dimension about the same as a perimeter of the sleeve tube 803 of the airbag 800 at the inflated state, i.e. sheet width $810W = \pi D3$.

The flat sheet 810 is folded along a middle line 815 and with the pair of long sides 812, 828 jointed to each other by e.g. stitching, sewing etc, forming a straight sleeve 830

with a sleeve length 830L the same as the sheet length 810L. The straight sleeve 830 has a first edge 832 which is formed by the pair of long sides 812 and 828 jointed to each other, and an opposite second edge 838 which is formed at the middle line 815 of the flat sheet 810. An array of evenly-pitched first wedge portions 833 is defined along the first edge 832 and linearly distributed over a full length of the straight sleeve 830. An array of evenly-pitched second wedge portions 840 is defined along the second edge 838 and linearly distributed over a full length of the straight sleeve 830. Each of the second wedge portions 840 is located between adjacent two of the first wedge portions 833.

Subsequently, the second edge 838 is pleated by folding the second wedge portions 840 into the straight sleeve 830, overlapping and stitching the second wedge portions, leaving the first wedge portions 833 unfolded to form a bent sleeve 850. The bent sleeve 850 is then flipped by swapping the external surface and the internal surface, such that the stitched portions of the long sides 812, 828 and the second wedge portions 840 become hidden in the bent sleeve 850. An air-generator e.g. a compress-air container or cylinder 890 is placed in the bent sleeve 850. The first end 802 and the second end 808 of the curved sleeve 830 are then sealed or covered to form an air-tight chamber in the bent sleeve 850, to form an air bag 800 as shown in Fig. 28. Air bag 800 can then be collapsed and further folded to fit in a holder 206 and mounted to the bottom rim 212 of the shell 210a of a helmet 210, in a manner similar to that described hereinbefore and in conjunction with Fig. 13. It should be appreciated that while Fig. 28 to Fig. 31 show a bent sleeve 850 made of eight segments of first wedges, a bent sleeve may be made of other numbers of segments of first wedges e.g. ten, twelve, eighteen first wedges, etc, and the more the first wedges are segmented, the closer the bent sleeve is to a circular / torus profiled air bag upon inflation.

In a method 950 of forming an air bag, as illustrated in Fig. 32, at step 952, a rectangle-shaped fabric is provided. The rectangle-shaped fabric has a pair of long sides and a pair of short sides. At step 954, the pair of long sides are jointed to form a straight sleeve. The straight sleeve has a first side edge, a second side edge, a first end and a second end. At step 956, the second side edge of the straight sleeve is pleated sleeve. At step 958, an air generator is placed in the bent sleeve. At step 960, the bent sleeve is

collapsed and at step 962, the first end and the second end of the bent sleeve is sealed to form an air-tight chamber in the bent sleeve.

Although embodiments of the present invention have been illustrated in conjunction with the accompanying drawings and described in the foregoing detailed description, it should be appreciated that the present invention is not limited to the embodiments disclosed. Therefore, the present invention should be understood to be capable of numerous rearrangements, modifications, alternatives and substitutions without departing from the spirit of the invention as set forth and recited by the following claims.

CLAIMS

1. A wearable apparatus comprising:
a base;
a control unit mounted to the base;
a folded airbag mounted to the base;
an ignitor disposed in the folded airbag and coupled to the control unit;
wherein the control unit is configured to detect an impact signal of the base and upon the impact signal reaching a predetermined threshold, the control unit activates the ignitor to inflate the folded airbag to form an inflated airbag.

2. The apparatus of claim 1, wherein the base is a helmet having a rigid shell, and the folded airbag is mounted to a bottom rim of the rigid shell.

3. The apparatus of claim 2, further comprising a holder in which the folded airbag is disposed, wherein the holder is detachably mounted to the bottom rim of the shell.

4. The apparatus of claim 3, wherein upon the folded airbag being inflated, the holder is detached from the helmet.

5. The apparatus of claim 2, wherein the control unit is mounted to an external top surface of the rigid shell and having an electrical cable embedded in the shell to electrically coupling the controller and the ignitor.

6. The apparatus of claim 5, wherein the ignitor is detachably coupled to the cable and upon inflation of the folded airbag, the ignitor is detached from the cable.

7. The apparatus of claim 2, wherein the folded airbag is formed of an open loop having a first end and a second end disposed adjacent to each other, the apparatus further comprises a first fastening member mounted to the first end and a second fastening member mounted to the second end and lockable to the first fastening

member to prevent the first and the second ends from separating from each other from the inflated airbag.

8. The apparatus of claim 1, wherein the control unit includes an accelerometer for detecting the impact signal, a processor coupled to the accelerometer for determining the impact signal with respect to the predetermined threshold.

9. The apparatus of claim 1, further comprising a housing into which the control unit is disposed, wherein the housing is detachably mounted to the base.

10. The apparatus of claim 1, wherein the folded airbag is shaped and dimensioned to conform to a body part of a user wearing the apparatus upon inflation.

11. The apparatus of claim 1, wherein the base is a cloth having a collar portion, a front portion and a back portion, and the folded airbag is mounted to each of the collar portion, the front portion and the back portion.

12. The apparatus of claim 1, further comprising a one-way safety valve coupled to the folded airbag and in fluid communication with an interior of the folded airbag, wherein upon an air pressure of the inflated airbag exceeds a predetermined pressure limit, the one-way safety valve is opened to release the air pressure.

13. A method of operating a wearable apparatus, the method comprising:

executing a loop comprising:

acquiring a movement data of the wearable apparatus;

determining a Movement Index based on the movement data;

determining if the Movement Index exceeds a predetermined Movement Index threshold; and

exiting the loop and inflating a folded airbag coupled to the wearable apparatus if the Movement Index exceeds the predetermined Movement Index threshold.

14. The method of claim 13, wherein the movement data includes an acceleration of the wearable apparatus.

15. The method of claim 14, wherein the movement data includes a speed of the wearable apparatus.

16. The method of claim 13, wherein the loop further comprises acquiring an inertia data of the wearable apparatus, wherein said inertia data is used to determine the Movement Index.

17. The method of claim 13, wherein the Movement Index includes a Collision Index based on an acceleration the wearable apparatus.

18. The method of claim 17, wherein the Collision Index is derived based on a speed of the wearable apparatus.

19. The method of claim 13, wherein the Movement Index includes an Injury Index based on the inertia data.