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(54) **METHOD FOR MONITORING AND MANAGING DRIVER ATTENTION LOADS**

VERFAHREN ZUR ÜBERWACHUNG UND LEITUNG VON BELASTUNGEN FÜR DIE AUFMERKSAMKEIT EINES FAHRERS

PROCEDE POUR SURVEILLER ET GERER LES EXIGENCES POSEES A UN PILOTE EN TERMES D'ATTENTION

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Description

TECHNICAL FIELD:

[0001] The present invention(s) relate to methods that facilitate driver safety; and more particularly, to remedies against the effects of drowsiness, distraction and similar compromising conditions to a driver's driving capabilities.

BACKGROUND OF THE INVENTION(S):

[0002] Drivers of all types of vehicles are often unaware of the effects that drowsiness and distraction have on their own abilities for vehicle control. Humans in general, and particularly as drivers, are poor judges of their own performance capabilities. Typically, a driver's self-impression of his or her capabilities is better than actuality. Even persons who have basically good driving skills, will not perform uniformly at all times when behind the wheel of a vehicle. Furthermore, there are many times during driving trips that very little demand is placed on the driver with respect to execution of driving tasks. As a result, drivers are lulled into states of mind where little attention is being devoted to the driving task. Not surprisingly, driver inattention is a leading cause of vehicular collisions, and especially automotive collisions. According to a Nation Highway and Transportation Safety Administration (NHTSA) study of over two and one-half million tow-away crashes in a year's time, driver inattention is a primary cause of collisions that accounts for an estimated twenty-five to fifty-six percent of crashes. In that study, inattention was defined as having three components: visual distraction, mental distraction (looking without seeing) and drowsiness. Common crash types caused by inattention are: rear-end collisions, collisions at intersection, collisions while lane changing or merging, road departures, single vehicle crashes, and crashes that occur on low speed limit roadways.

[0003] Drowsy drivers are a well known phenomenon. At least one survey has indicated that fifty-seven percent of drivers polled had driven while drowsy in the previous year, and twenty-three percent had actually fallen asleep at the wheel. It is known that fatigue impairs driver performance, alertness and judgment. Collisions caused by drowsiness are a serious road safety problem, and fatigue has been estimated to be involved in as many as twenty-three percent of all crashes.

[0004] From a technological perspective, there is an ongoing and rapid increase of new information systems and functionalities that may be used within vehicles including mobile telephones, navigation aids, the internet, and other types of electronic services. The effect of mobile telephone use on drivers has been foremost in the public eye because of their widespread use, but sales of navigation aids and IT services are also growing fast. Mobile telephones alone have been estimated to have caused 300-1000 fatalities in one years time in the United States, and this is projected to reach 4000 fatalities per year in 2004. Distractions such as handheld telephone use, sign reading, eating food, interaction with other passengers, observing objects and manipulating devices in-the vehicle have the potential for capturing a driver's attention in an excessive way and thus also compromising safety. It is especially important that driving safety not be compromised as these new types of services and activities become more common place in the driving environment.

[0005] Driver workload increases based on utilization of these new functionalities and technologies. In this context, "workload" should be understood to refer to how busy a person is and the amount of effort they need to perform required tasks. When a driver has many things to do and is experiencing high workload, a high attention demand is being made on the driver in that there is much to be done at the same time. Drivers often attend to things that are not related to driver control of the vehicle and are therefore technically irrelevant to the driving situation. These things are often called secondary tasks and are potential distracters from driver attention to primary driving tasks. A secondary task becomes a distraction (including visual-, auditory-, cognitive-, and biomechanical distractions) when the driver's attention is captured thereby to a degree that insufficient attention is left for the primary control tasks of driving. As a result, driving performance such as lane keeping and speed control are compromised as ultimately is safety.

[0006] Driving tasks and secondary tasks overlap in the sense that some secondary tasks are driving related as diagrammatically shown in Fig. 1. Two difficulties arise from this relationship between the driving and secondary tasks. First, it can be difficult to delineate which secondary task information is "irrelevant to the driving situation" and which is not; and second, certain driving related secondary tasks, for instance, looking for a street sign or planning a driving route may also compromise safety as graphically depicted in Fig. 1.

[0007] It should also be appreciated that the driver is often unaware of the effects of distraction on the driving task. Also, drivers cannot reliably determine when they are impaired by fatigue to the point of having a serious vigilance lapse or uncontrolled sleep attacks. The attention management systems outlined herein are intended to increase safety by assisting the driver in drowsy, distractive, and/or high workload situations.

[0008] Document US-A-5 786 765 discloses a method according to the preamble of claim 1.

SUMMARY OF THE INVENTION:

[0009] The attention management methods disclosed herein have as an objective to increase safety by assisting drivers in drowsy, distractive, and/or high workload situations. Functional specifications are provided for a number of attention management systems that can be characterized to include drowsiness managers, distraction managers, managers for distraction adaptation of forward collision and lane change warning systems, and workload managers that are at least in part controlled based on driving demand estimations observed or deduced from visual behavior of the driver. A hardware system that can be suitably employed to perform these driver attention management tasks is also described. A "platform" for development of the instant drowsiness and distraction manager based on Human Machine Interaction (HMI) is also disclosed, as is description of continuous and post-trip attention feedback systems. The HMI approach has as an objective thereof to counteract driver inattention by providing both imminent collision warnings, as well as attention-feedback to cause positive behavioral change.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0010]

Fig. 1 is a diagrammatical representation of the inter-relationship of driver driving tasks and driver secondary tasks;
Fig. 2 is a flowchart representing one embodiment of an attention management system that includes hardware and functional modules for sensing, computation, HMI, and electrical supply;
Fig. 3 is a diagrammatical representation of a platform upon which several drowsiness manager countermeasures may be exemplarily implemented;
Fig. 4 depicts exemplary representations of possible display warnings to a driver;
Fig. 5 depicts an exemplary, interactive, driver response panel;
Fig. 6 depicts an exemplary embodiment for driver gaze redirection;
Fig. 7 diagrammatically illustrates interaction of constituent components of driver inattentiveness;
Figs. 8(a)-(c) illustrate various "active" graphical displays for displaying real-time driver information according to the teachings of the present invention;
Fig. 9 provides an illustration of real-time driver feedback in a comparative format against an indication of an optimal level of attention;
Fig. 10 provides an illustration of an exemplarily formatted explanation of the basis for the detected increased workload/inattention level;
Fig. 11 provides an exemplary illustration of on-screen post-trip feedback;
Fig. 12 provides an exemplary illustration of a heads-up or screen display warning for forward collision situations;
Fig. 13 provides an exemplary illustration of a heads-up or screen display warning regarding lane-change collision situations;
Fig. 14 provides an exemplary flow chart for a method conducted according to the present invention in which a measure is made of a driver physiological characteristic such as head and/or eye movement. In another step, a behavior parameter is assessed such as level of driver distraction or attention load. In still another step, feedback regarding the assessment is made to the driver.

DETAILED DESCRIPTION OF THE INVENTION(S):

[0011] The invention is as disclosed in the appended set of claims.

[0012] In at least one embodiment, the present invention provides a method that enables the implementation of attention management concepts in a vehicle, including exemplary hardware upon which the inventive functionalities can be accomplished. Several basic questions and goals are addressed herein, including: what visually derived support do drivers need and how should it be conceptualized to achieve acceptance; how can real-time recognition of driver visual behavior be applied to reduce driving errors and prevent accidents; what is the commercial feasibility of implementation. Functional descriptions are provided for exemplary drowsiness managers; distraction managers, distraction adaptation of forward collision and lane change warning systems; and workload managers. Methods for implementing driving demand estimation from visual behavior are also included.

[0013] One or more of these methods are individually, as well as collectively, described as making-up a so-called attention management system. One possible component of the several inventions described herein, is the attention support demonstrator that can be used to implement these methods for demonstration and testing. Examples of driving demand estimation from visual behavior are also described herein.

[0014] In one embodiment, the attention management system includes hardware for (1) sensing, (2) computation, (3) HMI, and (4) electrical supply. The units or functional modules can be exemplarily configured (interrelated) as illustrated

in Fig. 2, and are suitable for implementation in such vehicles as automobiles and trucks.

[0015] A visual behavior sensor is employed such as that which is available from the company, SeeingMachines, and which can be adapted to be installed in a vehicle. This type of system can include (1) a stereo camera head, (2) a personal computer (PC), and (3) appropriate driving software. A visual behavior sensor such as that produced and sold under the trade name SMARTEYE may also be optionally employed.

[0016] Vehicle performance signals can be acquired from the CAN bus. A steering wheel angle sensor can also utilized, as well as lane tracking hardware and software. An annotation box and video recording hardware is utilized. An onboard personal computer, or similarly capable computing device is utilized. Alternatively, and especially to facilitate testing and implementation, a laptop computer can be employed that exemplarily runs such software as "Director" and "Simulink." An xPC can also be installed and utilized. From a hardware perspective, LED controller hardware is employed. Audio HMI (warning sounds, recorded messages) are provided for via the computing device. A touch-screen for user input can also be utilized. It should be appreciated that some of these embodiments are suitable for product development and facilitate system testing, but when commercialized, the several components are integrated directly into the vehicle.

[0017] A seat vibration arrangement or similar driver alert can be included. In a preferred embodiment, a LED HUD (heads up display) is employed. A LED array (display), controlled by a LED controller can also be utilized. An electrical supply for the entire system can be tapped from the carrying vehicle.

[0018] A drowsiness manager can be implemented in two configurations. In a first example, it is entirely PC based; that is, no external hardware or external communication capabilities are required. This embodiment is scenario based; that is, tracking of a drowsiness episode based on real PERCLOS (analysis that considers scan patterns, number and length of fixations, saccade latency and the like) data rather than in real-time. The hardware functionality stimulates the driver via such stimuli as a visual display such as LED-based or HUD, or physical stimulation such as seat vibration. In another embodiment, HMI hardware and Simulink communication is implemented.

[0019] A "platform" upon which several drowsiness manager countermeasures may be implemented is desirable, and upon which tests may be conducted. An exemplary platform for such implementation is schematically illustrated in Fig. 3.

[0020] The illustration of Fig. 3 may be considered to depict a director program. Such an arrangement is easy to change with respect to different HMI components; for instance, to provide (1) continuous information streaming to the driver, to provide (2) cautionary warnings, (3) eminent danger warning alarms, (4) driver response tests, (5) post trip summary information, and (6) operator input set-up menu(s).

[0021] In one embodiment of the invention, a caution warning to the driver is provided. The driver is able to choose between warning versions, but is not able to completely disable the warning. Exemplarily, a beep followed by an optional voice message warning can be played to the driver such as "<automated insertion of drowsiness cause>, 'take a break. ' " An icon can be alternatively displayed to the driver either individually, in conjunction with an audible warning, or together with a printed version of the warning.

[0022] Exemplary icon warnings are shown in Figs. 4(a)-(d) for (a) large eye closure detection, (b) inconsistent steering detection, (c) inconsistent lane-keeping detection, and (d) driver drowsiness detection. One or more of these icons can be simultaneously displayed depending upon detected driver conditions.

[0023] In another embodiment, a microphone is included so that the driver can record or supply his or her own warning much like in a telephone answering machine and other customizable audio play-back devices.

[0024] In still another embodiment, driver physical-stimulation warnings are applied. Preferably, the driver can choose between warning-types in the set-up menu, but in at least one embodiment the operator is prevented from completely disabling the physical warning. An example of such a physical stimulation would be seat vibration.

[0025] In another version, a flashing "HUD" LEDs may be used to sharply stimulate the driver; again, alone or in conjunction with the other types of warnings described herein. In a preferred embodiment, capabilities are provided to the driver for enabling up to three of the described warning types to be simultaneous presented when active.

[0026] A driver response functionality; that is, reaction-time to a signal, is also provided. With regard to this functionality, the driver is able to both enable and disable, as well as choose between warning versions in the set-up menu.

[0027] In a predetermined amount of time, for example five to eight seconds post-warning, a driver response function operates. Exemplarily, there will be a beep, with text "Press" under a button presented on a touch screen as illustrated in Fig. 5. If the driver does not react within the prescribed amount of time, or according to some other reaction time based algorithm, then an alarm warning will issue. This continues until the driver stops the vehicle, becomes alert and this fact is system-detected, or the driver turns the function off.

[0028] In order to provide customizing capabilities to the operator, exemplary options that may be selected via the HMI components are illustrated below:

HMI Component	Option(s)
(1) Continuous drowsiness feedback	Continuous feedback on/off

(continued)

HMI Component	Option(s)
	Choice of one of several versions
(2) Caution Warning	Voice message on/off Default message on/off User supplied message on/off Use multiple icons or Use default icon
(3) Alarm/Stimulation Warning	Choice of following (at least one must be checked) Seat vibration on/off Sound on/off HUD visual warning on/off Fan (not implemented in iteration 1) Scent (not implemented in iteration 1) Cut gas (not implemented in iteration 1) Drive to roadside(not implemented in iteration 1) Use multiple icons or Use default icon
(4) Driver Response	Driver response on/off

[0029] A distraction manager can be exemplarily implemented in two embodiments. In a first embodiment, the distraction manager is entirely PC based with no external hardware or communication capabilities. It is scenario based; that is, a timeline of a distraction episode is given rather than in real-time. The hardware functionality is simulated. A second embodiment is based on a hardware implementation that includes the capability of real time communication.

[0030] Another aspect of the invention is safety threshold based distraction warnings. Warnings are provided that inform the driver of safety compromising distractive behavior. As appreciated hereinabove, drivers are often unaware of the effects of their distraction on their driving capabilities. Thus a goal of the safety based distraction warnings is to give the driver feedback about driving control task performance decrements. That is, if distraction is detected (i.e. glance behavior is over an appropriate safety threshold and/or vehicle performance deteriorates during glance behavior), the system provides one or more of the following alerts. A sound such as a simple beep or a performance-specific voice message referring to which performance decrements have been detected may be provided. For example, if glance behavior is above *glance safety threshold standards* (e.g. EU recommended 4 glances or 2 second single glance duration, US AAA recommended 10 second total glance duration), then the message "Visual Distraction Detected" or "Eyes off road extensively" can be issued. If steering is deviant during *secondary task glance behavior,* then the message "Inconsistent steering during visual distraction" can be issued. If lane keeping is deviant during *secondary task glance behavior,* then a message such as "Inconsistent lane-keeping during visual distraction" can be provided. If large_speed_reduction is detected during *secondary_task_glance_behavior,* then a message such as "Large speed reduction during visual distraction" can be issued. If multiple_causes are detected, then a generic message such as "Visual distraction detected" can be issued. If control task intrusion is detected during *secondary task glance behavior,* during *different road types* or *different demand levels,* then a corresponding warning is issued. The form(s) of the warnings can include a driver recorded or provided message, a seat vibration in a front part of seat or gaze redirection as described hereinbelow.

[0031] The present invention disclosure includes a new concept of "gaze redirection" that is illustrated in Fig.6. Therein, an interface directs the driver's eyes to the forward driving scene (i.e.; through the front windshield) if driver distraction is detected. Exemplarily, a wave of light following one or more of the three LED "lines" (left, center; or right) will be initiated depending on where the drivers' gaze detected. After a wave of light, a large circle may optionally light up and then the central line of LEDs will light up; each purposed to more clearly focus the driver's attention where needed. The exact placement and timing of the several LED lights is not critical, nor is the color. In fact, the timing may be subliminal; that is, so fast that they are not consciously perceived. Alternatively, the appropriate lights may be first slowly flashed and the driver evaluated by the system to determine if corrective behavior has taken place. If not, the flash timing, as well as light intensity may be increased.

[0032] The set-up menu for distraction feedback may have exemplary logic as shown below:

HMI Component	Option(s)
(1) Continuous distraction feedback	Continuous distraction feedback on/off
(2) Safety threshold based distraction warning	Voice message on/off Performance specific message on/off Default/multiple cause message on/off User supplied message on/off Seat vibration on/off Gaze redirection on/off

[0033] In another aspect, the present invention incorporates the concept of workload management with driving demand estimation derived from visual behavior of the driver. In general, the concept of a "workload manager" is a prioritization system that categorizes information and potentially delays presentation of the information to the driver until his or her workload is sufficiently low to avoid risk associated with the information's reception. The interfaces of integrated, in-vehicle information systems can be adapted to ensure that proper attention is being given to the driving task. The output from the distraction management algorithms referenced herein can be used as input to workload managers.

[0034] Workload managers of the type disclosed herein accurately measure driver workload using the *driving demand visual activity* measure of driving demand. This is a measure of how "visually active" a driver is; that is, head and eye movement (rotation) variability. This measure of head and eye movement is described in greater detail in United States Provisional Patent Application No. 60/418,171 filed 15 October 2002 including the "visual activity" algorithm described therein. Furthermore, the *driving demand visual activity* measure also enables new functionality in the Workload Manager HMI, disclosed herein.

[0035] One aspect of the workload manager is to pause dialogue of audible conversation or information. As examples, this includes system-initiated or auto-initiated information (e.g. text-to-speech email and non-critical navigation system information) and randomly-initiated spoken dialogue (e.g. incoming and outgoing telephone conversations) can be paused during periods of high visual activity.

[0036] As an example, a series of emails can be being delivered to the driver, for example, ten new emails from memory that are being "read" out loud by a text-to-speech system. During the course of such audio transmission, a period of high driver visual activity is detected by the management system. In response, the system pauses the audio transmission to avoid increasing the driver's attention load beyond pre-selected levels; such levels exemplarily corresponding to attention loads beyond which driving capabilities are compromised. Optionally, the management system can include an audible indication to the driver of such interruption via a tone or the like which may also serve as notice to the driver of the high attention load condition. The audible transmission can be resumed based on driver initiation or system initiation that is dependent on the system's detection of a sufficient reduction in attention load to a pre-selected level exemplarily corresponding to safe conditions for driver receipt of such audible information.

[0037] In the present invention, continuous and/or post-trip attention load feedback is enabled via the disclosed management method. This aspect has been enabled pursuant to the fundamental human behavior characteristic commonly referred to as the feedback principle; such principle generally holding that feedback enhances performance. This is true for both task/skill learning (e.g. learning to drive safely) and for job motivation. As appreciated hereinabove, drivers are typically poor judges of their own performance. The degree to which direct, accurate, immediate, and continuous information on task/skill performance is available is a key element in enhanced driver performance and motivation. Attention feedback constitutes a form of intrinsic driving feedback that has heretofore been otherwise unavailable to the driver. The approach is one of positive behavioral adaptation and lifestyle change rather than imminent collision warning. For example, some researchers believe that the main mechanism for increased alertness is "decision influence." The concept of decision influence stipulates that information of this nature (driver attention load and state-of-alertness) will influence a driver's decision about whether to stop for rest, drink coffee, reduce alcohol consumption or change other such behaviors.

[0038] An objective of attention feedback is thus to encourage positive behavior change over one or more of a plurality (multiple) of time-frames, for instance: (1) immediate (e.g. short-term compensatory behaviors like changing posture or aborting a complicated task); (2) trip (e.g. stopping for a nap, turning off mobile phone); (3) day-to-day (sleeping more after a low attention day, removing video screen from front seat); (4) and long-term (adoption of a different sleep lifestyle or distraction attitude). This feedback increases driver self-awareness of inattentive behavior and enables better self-management.

[0039] Two main feedback types are considered. The first is continuous in-vehicle feedback that provides the driver with real-time attentive performance information, for example information presented while driving. This information is communicated in a way that, in itself, does not jeopardize safety. The concept is to provide a sort of attention-meter,

alertness meter (alert-o-meter), or safe/unsafe driving performance meter. The second feedback type is post-trip feedback that provides the driver with more detailed attentive performance information once driving has stopped.

[0040] Saving post-trip feedback "to file" further allows fleet-based safety feedback to focus on source behaviors as opposed to outcome measures such as accident incidents. One option, perhaps contributing to driver acceptance, is the provision of a tiered system. In such a tiered system, drivers have continuous access to data, fleet managers have access to summarized data, and regulating agencies can be granted access to summary data. Therefore, in the instance of fleet drivers, the invention can be better enjoyed as a helpful tool, without necessarily having to induce driver apprehension about employer-reporting characteristics.

[0041] To be able to give attention feedback, the management system has to be operationalized. Inattention may be seen as being comprised of drowsiness/impairment, distraction, and high workload factors. Therefore, and as illustrated in Fig. 7, an integrated model considering each type of inattentiveness is preferred. Therein, one method model configured according to the present invention is shown that can selectively consider driver inattention, workload, and personal characteristics such as drowsiness and distraction.

[0042] In another aspect of the present invention, unique ways are provided for displaying various information or feedback to the driver. In the instance of continuous attention-feedback, Figs. 8(a)-(c) demonstrate various "active" graphical displays for displaying real-time driver information that has been sensed or generated by the management system. As an example, the display can be of a "generic" or synthesized attention feedback quantity such as the level of attention/inattention as a combined measure of drowsiness, distraction, and workload. In the instance of Fig. 8(a), a simple stack of lights with no trend information is exemplified. In the instance of Fig. 8(b), an "aircraft radar type" display is utilized in which a box is positioned around the current level and trend information in the form of "fading out" is enabled. Fig. 8(c) demonstrates a histogram in which instantaneous "real time" information is shown as an elongating/retracting bar (relatively wide) on the right, with aggregate statistical values (average, median, and the like) for periods of pre-selected duration represented by the more narrow bars on the left. In this manner, trend information is demonstrated. In the illustrative example of Fig. 8(c), five previous periods are represented. It should be appreciated that any previous periods may be displayed according to the control logic for the display and memory capacity.

[0043] In another aspect, the present invention also provides real-time driver feedback in a comparative format against an indication of an optimal level of attention. An exemplary embodiment of such a display is illustrated in Fig. 9 where a driver may observe his or her degree of distraction or overload relative to optimum attentiveness.

[0044] In still another aspect, the invention may be used to measure detected periods of driver inattention, with notification of the state provided. The driver may then "ask" (e.g. by touching a screen, for instance) what the problem was and receive an explanation of the basis for the detected increased workload/inattention level. Such feedback can exemplarily be provided in the form of verbal messages and/or graphically as shown in Fig. 10. Therein, three graphic representations of drowsiness, distraction, and workload are depicted on the right, and a combination of the effects is demonstrated on the left where relative driver attentiveness is indicated.

[0045] As explained above, the aspect of trip-reporting can be highly advantageous for the driver's learning and behavior modification. Therefore, inventive ways to provide on-screen post-trip feedback are disclosed and exemplarily illustrated in Fig. 11. In this illustrative example, a menu choice from a display screen has been selected for post-trip feedback and the associated display of such measured characteristics as percent eye-closure, steering consistency and the like have been displayed in a historical format. Of course, this same information can advantageously be logged for later analysis and use.

[0046] The driver capabilities that have been discussed above can also be utilized for distraction adaptation of other vehicle systems such as forward-collision, rear-collision and lane-change collision warning (FCW, RCW and LCW) systems. Rear-end collisions account for approximately twenty-eight percent of automotive crashes. Because driver inattention is a contributing factor in more than sixty percent of these collisions, collision warning and avoidance systems are important tools for reducing crashes and saving lives. One objective of the present attention management systems is to detect the co-occurrence of inattention and safety critical events in the traffic environment; for example, sudden braking of a lead vehicle and driver eyes-off-road conditions. Two examples of this can be used as visual behavior information to adapt forward collision- and lane change- warnings.

[0047] Integration of detection of quantified secondary tasks (e.g. by detecting button presses or eye movements) greatly enhances the collision warning system by dynamically adjusting the collision warning threshold according to whether the driver is engaged with a potentially distracting device or other type task. For example, the collision warning system could generate a warning earlier if it is detected that the driver is involved in a cellular telephone conversation. An early collision warning helps the driver react more quickly and avoid more collisions compared to late warning, or no warning at all. If the driver is inattentive with respect to a certain aspect of the driving task, for example looking away from forward when a likelihood of forward collision is detected, or has not looked sideways when a possible lane change collision is detected, then warnings of such conditions are initiated earlier. Studies have shown that even a one second earlier warning when drivers are looking away is highly effective for avoiding collisions.

[0048] If it is detected that the driver is attentive, then the warnings can be delayed or even cancelled. A delay in

warning presentation allows more time for the forward collision and lane change warning algorithms to more certainly ascertain that a warning is needed, thereby reducing false alarms. Still further, driver cancellation wherein the driver chooses not to have collision warnings active when looking at the road or side mirrors would also eliminate annoying false alarms.

[0049] As an implementation strategy, in a first stage, such warnings may be "soft," but increasing in intensity as conditions worsen and a crash becomes more imminent. In the instance of forward collision warning, a heads-up or screen display warning may first be called up, but later being joined by an audible warning sounded as crash conditions intensify. An example of such a warning and its control parameters (which may or may not be displayed to the driver) are depicted in Fig. 12 regarding forward collision situations and Fig. 13 regarding lane-change collision situations.

[0050] The detection features described hereinabove with regard to driver characteristics may be utilized in other environments and for other purposes than expressly described. The detection features may also be integrated for employment in other in-vehicle systems. For instance, as a passive safety feature, a "smart" airbag may be enabled that detects when the driver's/passenger's head is not in a proper position to receive a deployed airbag. Responsively, deployment of the airbag may be modified to accommodate the sensed head position.

[0051] In another capacity, sensed behavior could be used to identify the driver, or at least rule out that an authorized driver is behind the wheel thereby facilitating theft protection. The head and eye sensors could also be used to automatically configure mirrors, seat positions and the like. Mouth tracking can be used to enhance speech recognition accessories. Filters for oncoming headlights can be adapted, as can displays for the driver based on eye position and motion.

Claims

1. Method for enhancing driving performance by monitoring a driver's attention to driving tasks, the method comprising the steps of:

   - measuring a visual activity of the driver based on the driver's head and/or eye movement;
   - assessing a driver's level of attention to driving tasks based on the measured visual activity; and **characterized in that** it comprises the step of
   - informing the driver of his attention to driving tasks by providing a continuous and/or post-trip attention feedback to the driver by outputting information data through a human-machine interface.

2. The method according to claim 1, wherein the step of assessing the driver's level of attention comprises the step of considering drowsiness or impairment, distraction and high workload factors, wherein preferably each type of inattentiveness is considered.

3. The method according to claim 2, wherein said step of outputting information data comprises at least one step selected from a group consisting of outputting visual information data on a screen display; outputting visual information data on a head-up display; and outputting spoken information on an voice output.

4. The method according to any one of the preceding claims, wherein the continuous attention feedback is a real-time attentive performance information, particularly an attention meter, an alertness meter or a safe/unsafe driving performance meter, which is preferably presented while driving.

5. The method according to claim 4, wherein the real-time information is displayed as graphical display, preferably showing the level of attention/inattention as combined measure of drowsiness, distraction and workload.

6. The method according to claim 5, wherein the graphical display can be adapted to show a graphical representation for each of drowsiness, distraction and workload.

7. The method according to claim 5 or 6, wherein the graphical display is a stack of lights.

8. The method according to any one of claims 4 to 7, wherein the real time information also provides trend information.

9. The method according to claim 8, wherein the graphical display is of an "aircraft radar type", which shows the current level of attentiveness and provides trend information by fading.

10. The method according to claim 9, wherein the graphical display provides a histogram of the driver's attention to

driving control tasks over a given period of time.

11. The method according to claim 10, wherein an instantaneous real-time information is shown as elongating/retracting bar and trend information is given by bars indicating aggregate statistical values for periods of preselected duration.

12. The method according to any preceding claim, wherein said step of informing the driver comprises a step of providing a scaled comparison between the driver's attention to driving control tasks and at least one normative value.

13. The method according to any one of claims 1 to 4, wherein the post-trip feedback is stored attentive performance information, which is provided once driving has stopped.

14. The method according to claim 13, the post-trip feedback is displayed as graphical display on a display screen.

15. The method according to claims 14, wherein the post-trip feedback is a detailed attentive performance information giving information on measured characteristics in a historical format.

16. The method according to any one of claims 13 to 15, further comprising the step of saving the post-trip feedback to file for later analysis and use.

17. The method according to claim 16, further comprising the step of providing the post-trip feedback data to a fleet manager, preferably in a tiered system as summarized data.

18. The method according to any preceding claim, comprising at least one of the steps of: measuring a driver's eye-gaze direction, measuring a drivers eye-closure amount, measuring a driver's blinking movement, measuring a driver's head position, measuring a driver's head orientation, measuring driver's movable facial features measuring a driver's facial temperature image.

19. The method according to any preceding claim, further comprising the step of measuring a grip force on a steering wheel and/or measuring a movement of a steering column.

20. The method according to any preceding claim, wherein the assessment of the driver's attention comprises one or more steps selected from a group consisting of :

- assessing a time weighted parameter characterizing a driver's eye movement over a predetermined period of time;
- assessing a time weighted parameter characterizing a driver's off-road eye-gaze over a predetermined period of time;
- assessing a time weighted parameter characterizing a driver's blinking movement over a predetermined period of time;
- assessing a time weighted parameter characterizing a driver's eye closure over a predetermined period of time;
- assessing a time weighted parameter characterizing a driver's head position over a predetermined period of time; and
- assessing a time weighted parameter characterizing a driver's head movement over a predetermined period of time.

Patentansprüche

1. Verfahren zum Verbessern des Fahrverhaltens, indem eine Aufmerksamkeit des Fahrers auf seine Fahraufgaben überwacht wird, wobei das Verfahren folgende Schritte umfasst:

- Messen einer visuellen Aktivität des Fahrers basierend auf Bewegung des Kopfes und/oder der Augen des Fahrers;
- Abschätzen eines Grades der Aufmerksamkeit des Fahrers auf seine Fahraufgaben basierend auf der gemessenen visuellen Aktivität;

dadurch gekennzeichnet, dass das Verfahren folgenden Schritt aufweist:

- Informieren des Fahrers über seiner Aufmerksamkeit auf seine Fahraufgaben, indem dem Fahrer eine kontinuierliche Rückmeldung über seine Aufmerksamkeit und/oder eine Rückmeldung über seine Aufmerksamkeit

am Fahrtende zu Verfügung gestellt wird, wobei Informationsdaten über eine Mensch-Maschine-Schnittstelle ausgegeben werden.

2. Verfahren nach Anspruch 1, wobei der Schritt des Abschätzens des Grades der Aufmerksamkeit des Fahrers den Schritt des Berücksichtigens von Faktoren hinsichtlich Müdigkeit oder Unzulänglichkeit, Ablenkung und Arbeitsbelastung umfasst sind, wobei vorzugsweise jede Art der Unaufmerksamkeit berücksichtigt wird.

3. Verfahren nach Anspruch 2, wobei der Schritt des Ausgebens der Informationsdaten zumindest einen Schritt umfasst, der aus einer Gruppe ausgewählt ist, bestehend aus: Ausgeben von visuellen Informationen auf einem Display; Ausgeben von visuellen Informationen auf einem Head-up Display; und Ausgeben von gesprochenen Informationen durch eine Sprachausgabe.

4. Verfahren nach einem der vorhergehenden Ansprüche, wobei die kontinuierliche Rückmeldung eine Echtzeit-Aufmerksamkeitsleistungsinformation, insbesondere eine Aufmerksamkeitsmessanzeige, eine Wachheitsmessanzeige oder eine Fahrleistung-sicher/unsicher-Messanzeige, ist, die vorzugsweise während des Fahrens angezeigt wird.

5. Verfahren nach Anspruch 4, wobei die Echtzeitinformation als graphische Anzeige angezeigt ist, wobei vorzugsweise der Grad der Aufmerksamkeit/Unaufmerksamkeit als kombiniertes Maß aus Müdigkeit, Ablenkung und Arbeitsbelastung angezeigt ist.

6. Verfahren nach Anspruch 5, wobei die graphische Anzeige anpassbar ist, um eine graphische Entsprechung für jeweils Müdigkeit, Ablenkung und Arbeitsbelastung anzuzeigen.

7. Verfahren nach Anspruch 5 oder 6, wobei die graphische Anzeige eine Lichterreihe ist.

8. Verfahren nach einem der Ansprüche 4 bis 7, wobei die Echtzeitinformation auch Trendinformationen bereitstellt.

9. Verfahren nach Anspruch 8, wobei die graphische Anzeige eine Art Flugzeugradaranzeige ist, die durch Überblendung den momentanen Grad der Aufmerksamkeit anzeigt und Trendinformation ausgibt.

10. Verfahren nach Anspruch 9, wobei die graphische Anzeige ein Histogramm der Aufmerksamkeit des Fahrers hinsichtlich der Fahrkontrollaufgaben über eine gewisse Zeitspanne bereitstellt.

11. Verfahren nach Anspruch 10, wobei eine instantane Echtzeitinformation als verlängerbarer/verkürzbarer Balken dargestellt wird und die Trendinformation durch Balken ausgegeben wird, die kumulierte statistische Werte für Zeitspannen vorbestimmter Länge anzeigen.

12. Verfahren nach einem der vorhergehenden Ansprüche, wobei der Schritt des Informierens des Fahrers den Schritt des Bereitstellens eines skalierten Vergleichs zwischen Aufmerksamkeit des Fahrers auf seine Aufgaben beim Fahrzeugsteuern und zumindest eines normativen Werts aufweist.

13. Verfahren nach einem der Ansprüche 1 bis 4, wobei die Rückmeldung am Fahrtende als Aufmerksamkeitsleistungsinformation gespeichert ist, die bereitgestellt wird sobald die Fahrt beendet wird.

14. Verfahren nach Anspruch 13, wobei die Rückmeldung am Fahrtende als graphische Anzeige auf einem Display angezeigt wird.

15. Verfahren nach Anspruch 14, wobei die Rückmeldung am Fahrtende eine detaillierte Aufmerksamkeitsleistungsinformation ist, die Informationen über gemessene Charakteristiken in einem Verlaufsformat ausgibt.

16. Verfahren nach einem der Ansprüche 13 bis 15, weiterhin umfassend den Schritt des Speicherns der Rückmeldung am Fahrtende in einer Datei für eine spätere Analyse und einen späteren Gebrauch.

17. Verfahren nach Anspruch 16, weiterhin umfassend den Schritt des Bereitstellens der Rückmeldungsdaten am Fahrtende für einen Flottenmanager, vorzugsweise als zusammengefasste Daten in einem abgestuften System.

18. Verfahren nach einem der vorhergehenden Ansprüche, umfassend zumindest einen der folgenden Schritte: Messen

einer Blickrichtung der Augen des Fahrers, Messen einer Menge von Augen-geschlossen Zuständen des Fahrers, Messen einer Blinzelbewegung des Fahrers, Messen einer Kopfposition des Fahrers, Messen einer Kopfausrichtung des Fahrers; Messen einer beweglichen Gesichtscharakteristik des Fahrers, Messen eines Temperaturabbildes der Gesichtstemperatur des Fahrers.

19. Verfahren nach einem der vorhergehenden Ansprüche, weiterhin den Schritt umfassend des Messens einer Griffstärke am Lenkrad und/oder den Schritt des Messens einer Bewegung an einer Lenksäule.

20. Verfahren nach einem der vorhergehenden Ansprüche, wobei die Abschätzung der Aufmerksamkeit des Fahrers einen oder mehrere Schritte umfasst aus der Gruppe bestehend aus:

- Abschätzen eines zeitgewichteten Parameters, der eine Augenbewegung des Fahrers über eine vorbestimmte Zeitspanne charakterisiert;
- Abschätzen eines zeitgewichteten Parameters, der eine Straßen abgewandte Blickrichtung des Fahrers über eine vorbestimmte Zeitspanne charakterisiert;
- Abschätzen eines zeitgewichteten Parameters, der eine Blinzelbewegung des Fahrers über eine vorbestimmte Zeitspanne charakterisiert;
- Abschätzen eines zeitgewichteten Parameters, der einen Augen-geschlossen-Zustand des Fahrers über eine vorbestimmte Zeitspanne charakterisiert;
- Abschätzen eines zeitgewichteten Parameters, der eine Kopfposition des Fahrers über eine vorbestimmte Zeitspanne charakterisiert;
- Abschätzen eines zeitgewichteten Parameters, der eine Kopfbewegung des Fahrers über eine vorbestimmte Zeitspanne charakterisiert.

Revendications

1. Procédé pour renforcer la performance de conduite en surveillant l'attention d'un conducteur vis-à-vis des tâches de conduite, le procédé comprenant les étapes consistant à :

- mesurer une activité visuelle du conducteur sur la base d'un mouvement de la tête et/ou de l'oeil du conducteur ;
- établir un niveau d'attention du conducteur vis-à-vis des tâches de conduite sur la base de l'activité visuelle mesurée ; et **caractérisé en ce qu'**il comporte l'étape consistant à :

  - informer le conducteur de son attention vis-à-vis des tâches de conduite en fournissant au conducteur une rétroaction d'attention continue et/ou après trajet par émission de données d'informations à travers une interface homme-machine.

2. Procédé selon la revendication 1, dans lequel l'étape consistant à établir le niveau d'attention du conducteur comprend l'étape consistant à considérer la somnolence ou la déficience, ou la distraction et des facteurs de charge de travail élevée, dans lequel de préférence chaque type d'inattention est considéré.

3. Procédé selon la revendication 2, dans lequel l'étape consistant à émettre des données d'informations comprend au moins une étape sélectionnée parmi un groupe constitué de données d'informations visuelles un groupe consistant à émettre des données d'informations visuelles sur un affichage par écran ; à émettre des données d'informations visuelles sur un affichage tête haute ; et à émettre des informations parlées sur une sortie vocale.

4. Procédé selon l'une quelconque des revendications précédentes, dans lequel la rétroaction d'attention continue est une information de performance d'attention en temps réel, en particulier un dispositif de mesure d'attention, un dispositif de mesure de réflexes ou un dispositif de mesure de performance de conduite sûre/non sûre, qui est de préférence présentée tout en conduisant.

5. Procédé selon la revendication 4, dans lequel les informations en temps réel sont affichées sous la forme d'un affichage graphique, de préférence représentant le niveau d'attention/inattention sous la forme d'une mesure combinée de somnolence, distraction et charge de travail.

6. Procédé selon la revendication 5, dans lequel l'affichage graphique peut être adapté pour être une représentation graphique de chacune parmi la somnolence, la distraction et la charge de travail.

7. Procédé selon les revendications 5 ou 6, dans lequel l'affichage graphique et un empilage de lampes.

8. Procédé selon l'une quelconque des revendications 4 à 7, dans lequel les informations en temps réel fournissent aussi des informations de tendance.

9. Procédé selon la revendication 8, dans lequel l'affichage graphique est du « type radar d'avion », qui présente le niveau courant d'attention et fournit une information de tendance par affaiblissement.

10. Procédé selon la revendication 9, dans lequel l'affichage graphique fournit un histogramme de l'attention du conducteur vis-à-vis des taches de commande de conduite sur une période de temps donnée.

11. Procédé selon la revendication 10, dans lequel des informations en temps réel instantanées sont représentées sous la forme de barres s'agrandissant / se rétractant et les informations de tendance sont donnés par des barres indiquant des valeurs statistiques cumulées pour des périodes de durée présélectionnée.

12. Procédé selon l'une quelconque des revendications précédentes, dans lequel l'étape consistant à informer le conducteur comprend une étape consistant à fournir une comparaison mise à l'échelle entre l'attention du conducteur vis-à-vis des taches de commande de conduite et au moins une valeur normative.

13. Procédé selon l'une quelconque des revendications 1 à 4, dans lequel la rétroaction après trajet est mémorisée en informations de performance d'attention, qui sont fournies une fois que la conduite a cessé.

14. Procédé selon la revendication 13, dans lequel la rétroaction après trajet est affichée sous la forme d'un affichage graphique sur un écran d'affichage.

15. Procédé selon la revendication 14, dans lequel la rétroaction après trajet est une information de performance d'attention détaillée donnant une information concernant les caractéristiques mesurées sous un format d' historique.

16. Procédé selon l'une quelconque des revendications 13 à 15, comprenant de plus l'étape consistant à sauvegarder la rétroaction après trajet dans un fichier pour analyse et utilisation ultérieures.

17. Procédé selon la revendication 16, comprenant de plus l'étape consistant à fournir les données de rétroaction après trajet à un gestionnaire de flotte, de préférence dans un système étagé sous la forme de données additionnées.

18. Procédé selon l'une quelconque des revendications précédentes, comprenant au moins une des étapes consistant à : mesurer une direction du regard de l'oeil du conducteur, mesurer une quantité de fermetures de l'oeil du conducteur, mesurer un mouvement de clignotement du conducteur, mesurer une position de tête du conducteur, mesure une orientation de la tête du conducteur

19. Procédé selon l'une quelconque des revendications précédentes, comprenant de plus l'étape consistant à mesurer une force de saisie sur un volant et/ou mesurer un déplacement d'une colonne de direction.

20. Procédé selon l'une quelconque des revendications précédentes, dans lequel l'établissement de l'attention du conducteur comprend une ou plusieurs étapes sélectionnées parmi un groupe constitué de :

- détecter un paramètre pondéré temporellement caractérisant un déplacement de l'oeil du conducteur sur une période de temps prédéterminée ;
- détecter un paramètre pondéré temporellement caractérisant un regard du conducteur fixant en dehors de la route sur une période de temps prédéterminée ;
- détecter un paramètre pondéré temporellement caractérisant un mouvement de clignement du conducteur sur une période de temps prédéterminée ;
- détecter un paramètre pondéré temporellement caractérisant une fermeture de l'oeil du conducteur sur une période de temps prédéterminée ;
- détecter un paramètre pondéré temporellement caractérisant une position de tête du conducteur sur une période de temps prédéterminée ; et
- détecter un paramètre pondéré temporellement caractérisant un mouvement de tête du conducteur sur une période de temps prédéterminée.

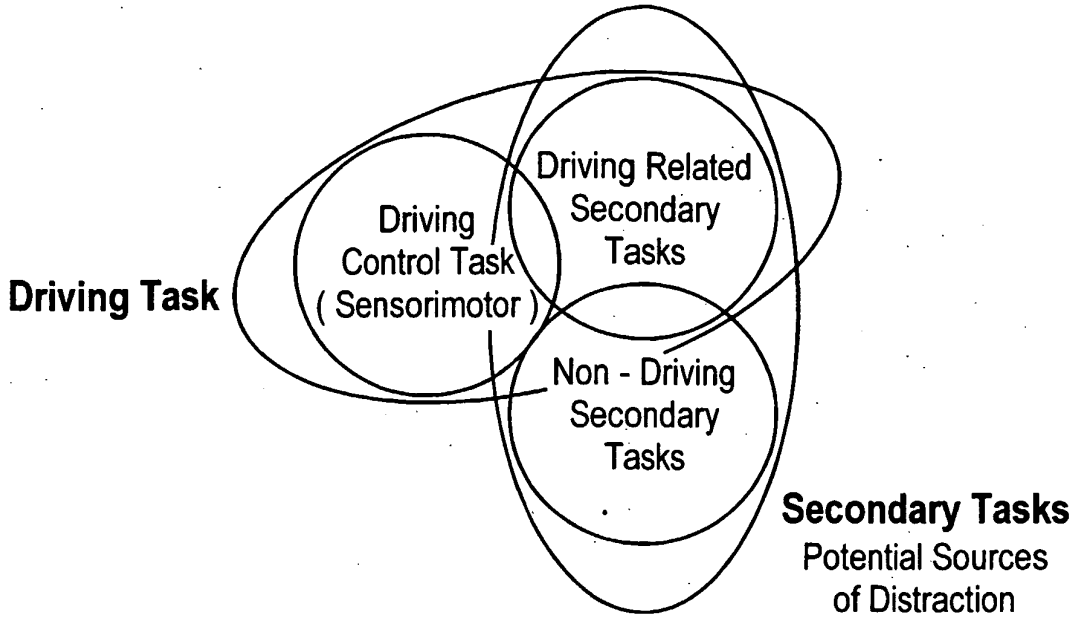
Driving Task
Driving Control Task (Sensorimotor)
Driving Related Secondary Tasks
Non - Driving Secondary Tasks
Secondary Tasks
Potential Sources of Distraction

FIG. 1

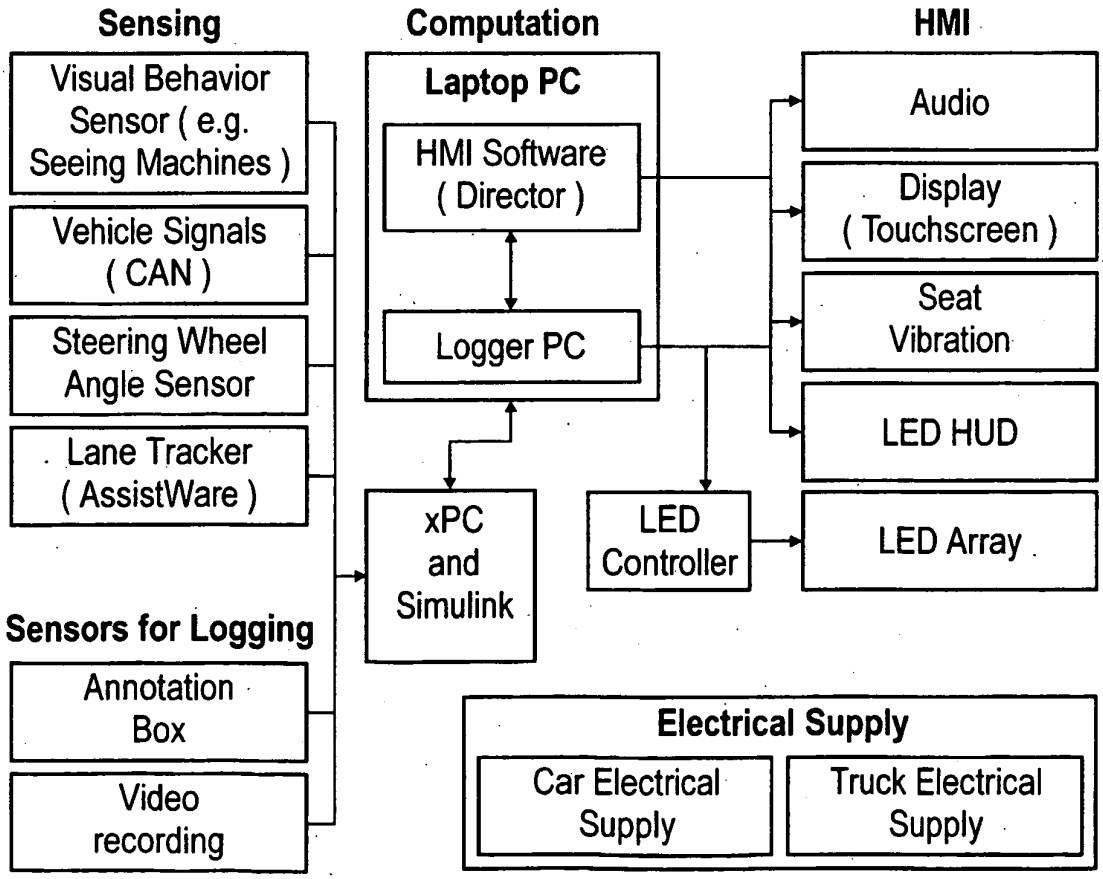
Sensing
Computation
HMI
Visual Behavior Sensor (e.g. Seeing Machines)
Vehicle Signals (CAN)
Steering Wheel Angle Sensor
Lane Tracker (AssistWare)
Laptop PC
HMI Software (Director)
Logger PC
xPC and Simulink
LED Controller
Audio
Display (Touchscreen)
Seat Vibration
LED HUD
LED Array
Sensors for Logging
Annotation Box
Video recording
Electrical Supply
Car Electrical Supply
Truck Electrical Supply

FIG. 2

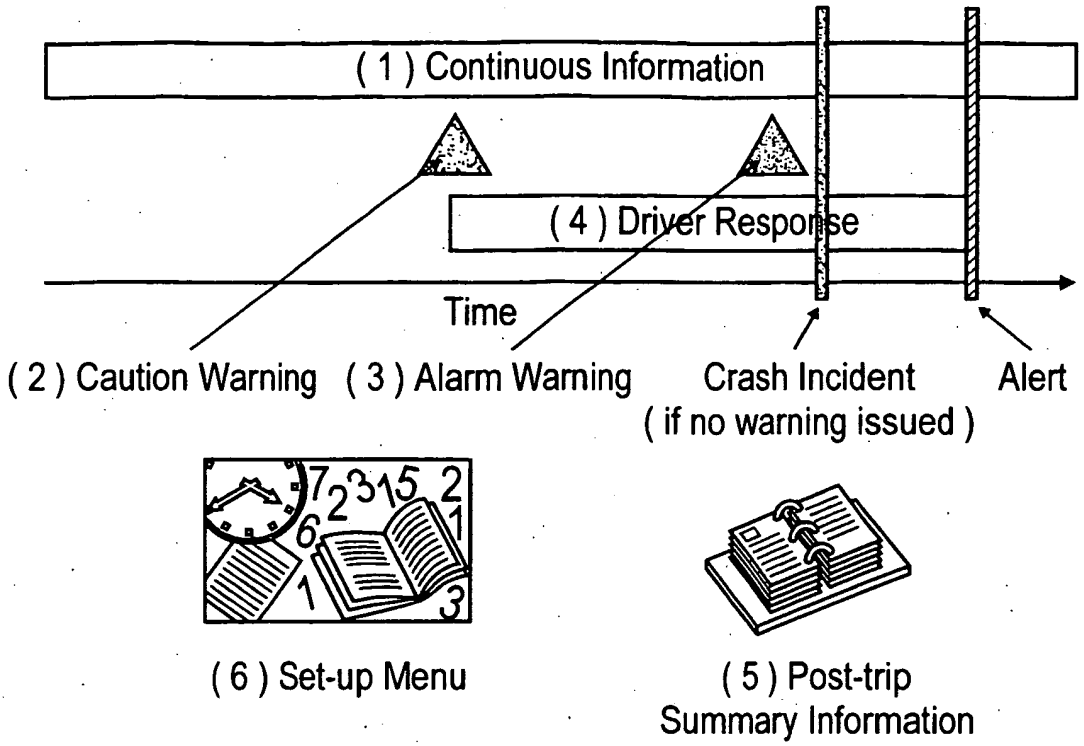

FIG. 3

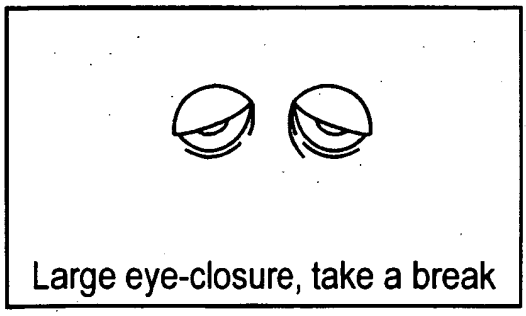

FIG. 4a

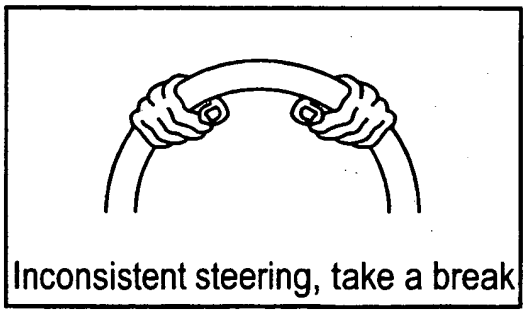

FIG. 4b

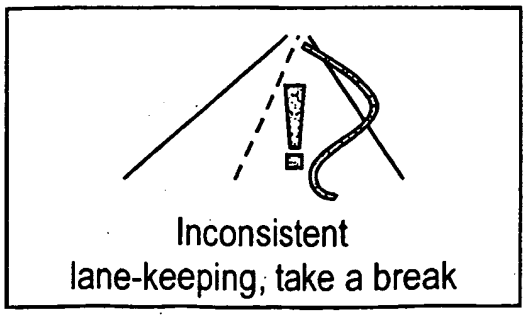

FIG. 4c

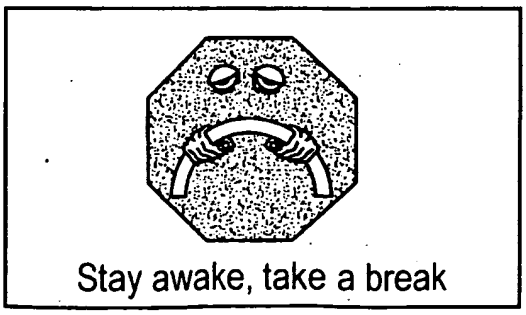

FIG. 4d

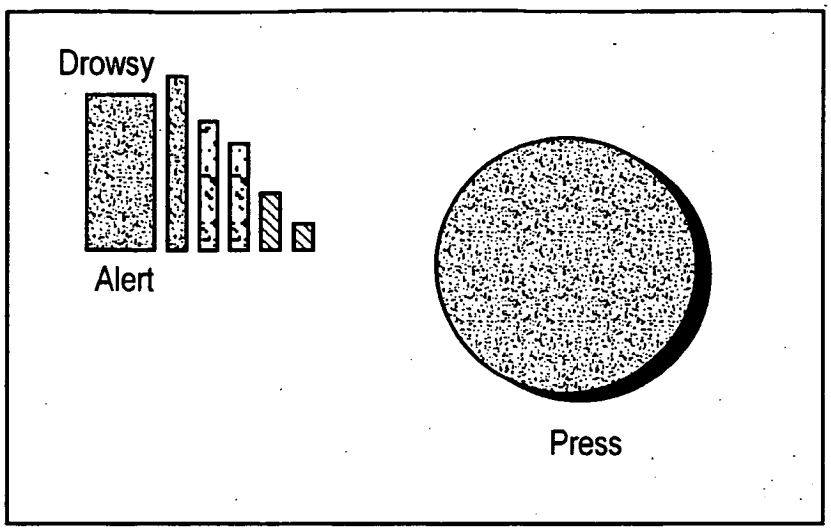

FIG. 5

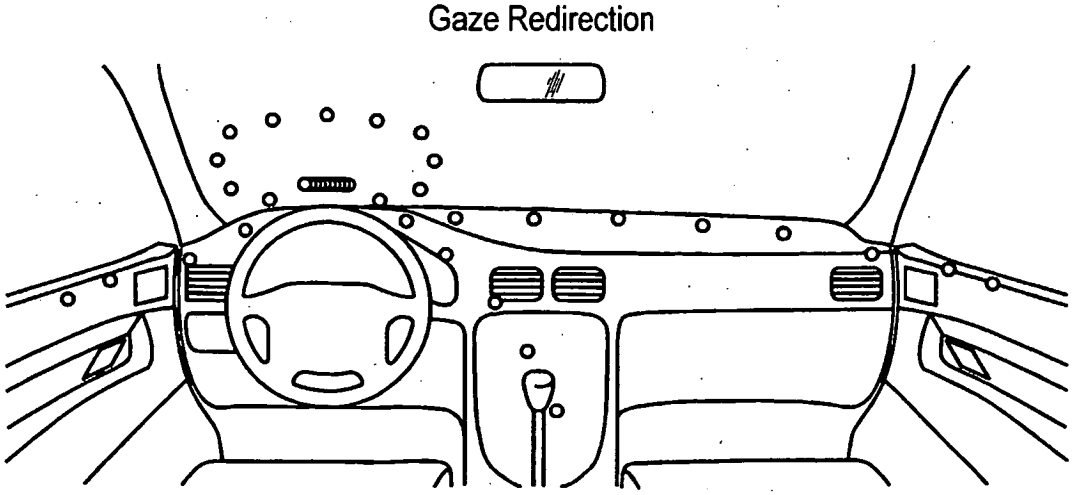

FIG. 6

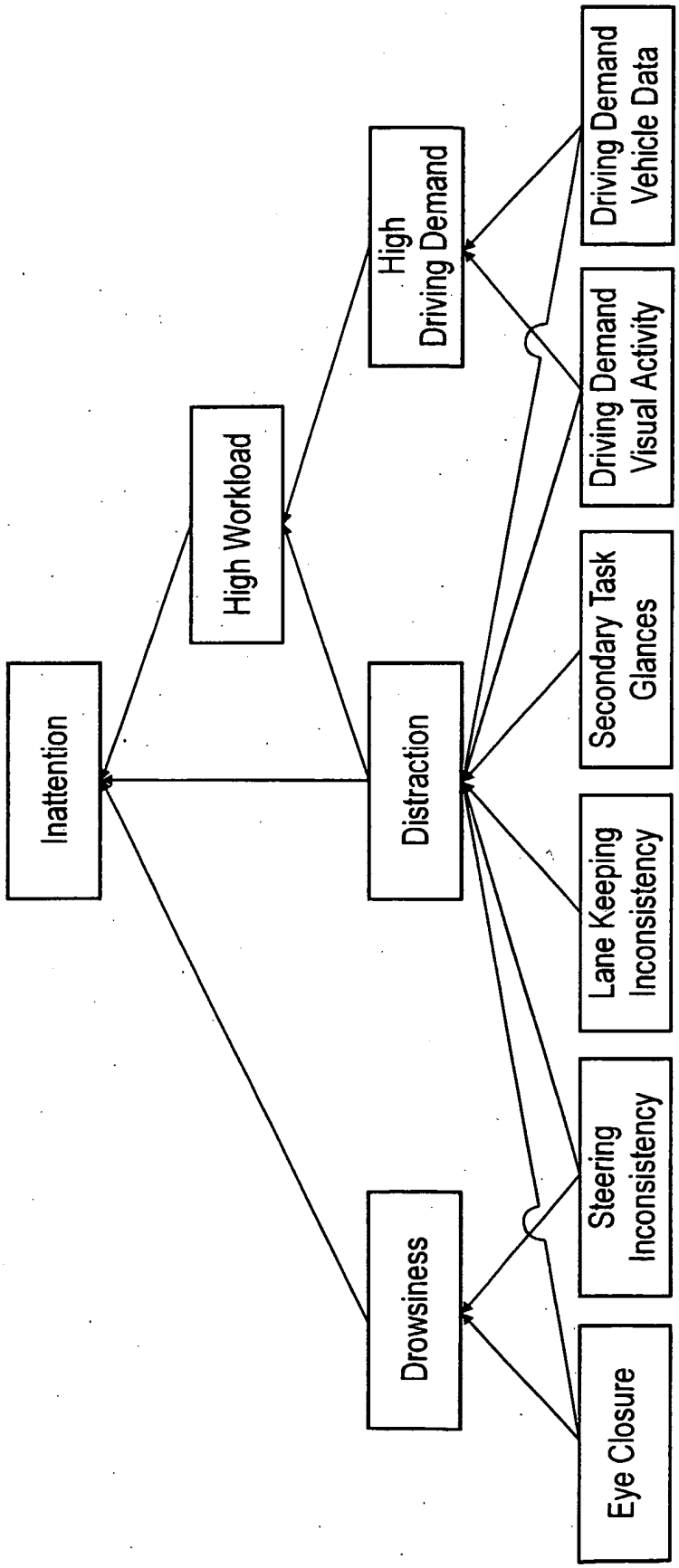
Inattention
High Workload
High Driving Demand
Distraction
Drowsiness
Driving Demand Vehicle Data
Driving Demand Visual Activity
Secondary Task Glances
Lane Keeping Inconsistency
Steering Inconsistency
Eye Closure

FIG. 7

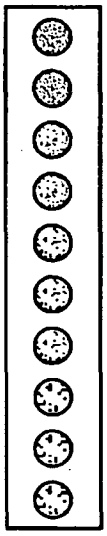

FIG. 8a

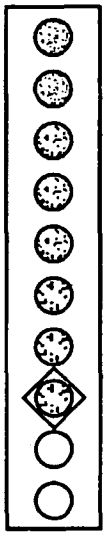

FIG. 8b

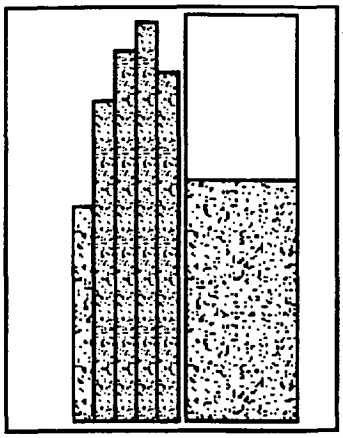

FIG. 8c

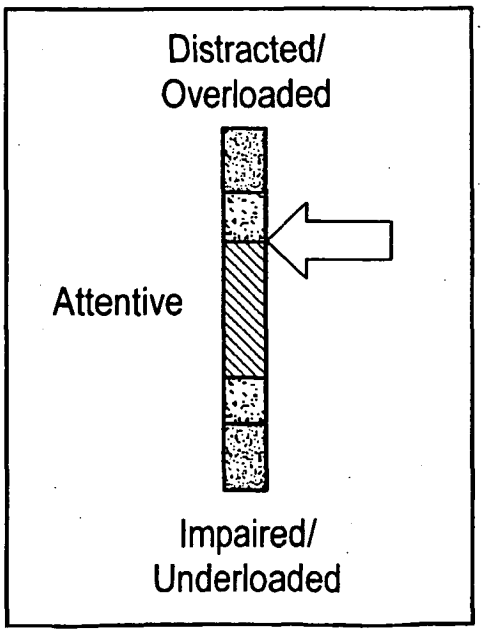

FIG. 9

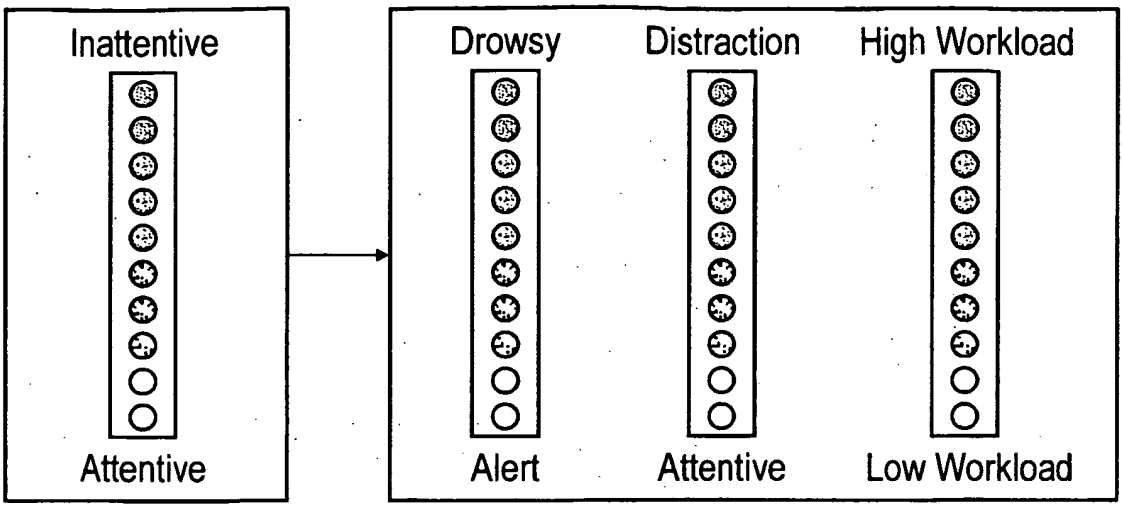
Inattentive
Attentive
Drowsy
Distraction
High Workload
Alert
Attentive
Low Workload

FIG. 10

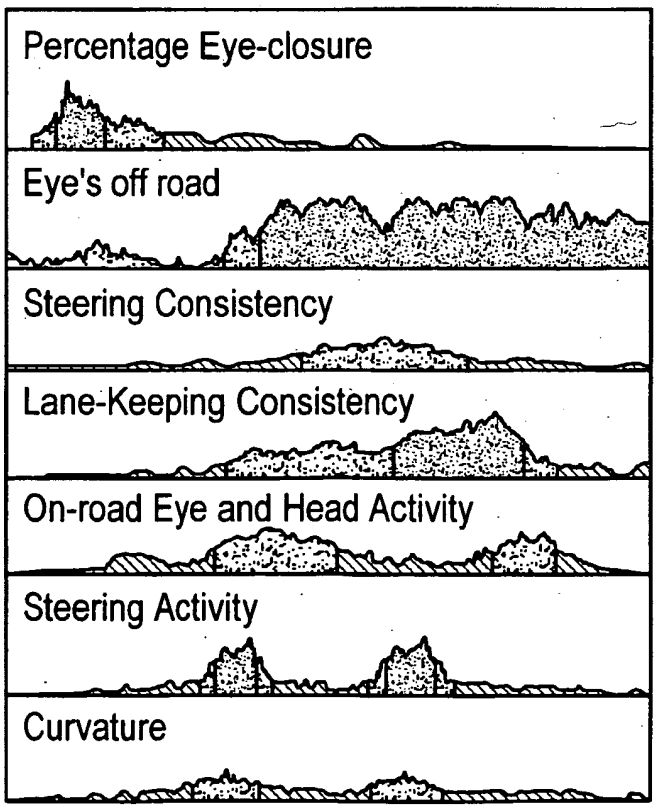
Percentage Eye-closure
Eye's off road
Steering Consistency
Lane-Keeping Consistency
On-road Eye and Head Activity
Steering Activity
Curvature

FIG. 11

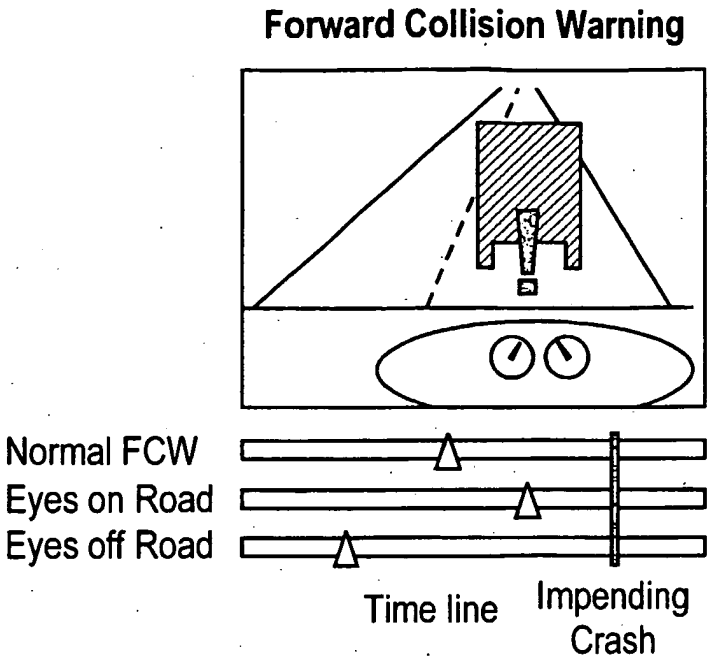
Forward Collision Warning
Normal FCW
Eyes on Road
Eyes off Road
Time line
Impending Crash

FIG. 12

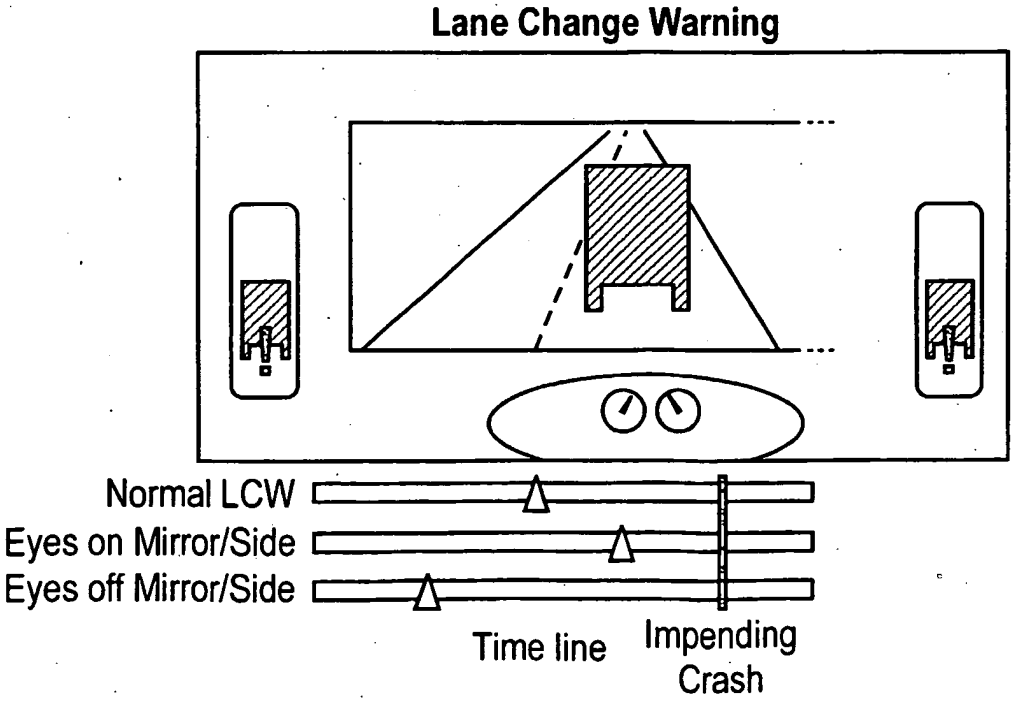
Lane Change Warning
Normal LCW
Eyes on Mirror/Side
Eyes off Mirror/Side
Time line
Impending Crash

FIG. 13

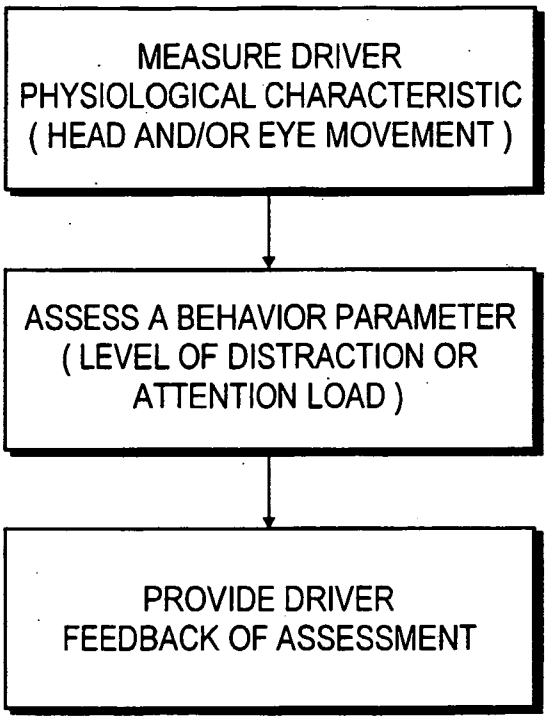
MEASURE DRIVER PHYSIOLOGICAL CHARACTERISTIC (HEAD AND/OR EYE MOVEMENT)
ASSESS A BEHAVIOR PARAMETER (LEVEL OF DISTRACTION OR ATTENTION LOAD)
PROVIDE DRIVER FEEDBACK OF ASSESSMENT

FIG. 14

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 5786765 A **[0008]**
- US 60418171 B **[0034]**

专利名称(译)	监视和管理驾驶员注意力负荷的方法		
公开(公告)号	EP1478268B1	公开(公告)日	2012-06-20
申请号	EP2003742752	申请日	2003-02-19
[标]申请(专利权)人(译)	沃尔沃技术公司		
申请(专利权)人(译)	VOLVO科技股份有限公司		
当前申请(专利权)人(译)	VOLVO科技股份有限公司		
[标]发明人	VICTOR TRENT		
发明人	VICTOR, TRENT		
IPC分类号	A61B5/00 A61B3/113 A61B5/11 A61B5/18 G08B21/06		
CPC分类号	A61B3/113 A61B5/015 A61B5/11 A61B5/1103 A61B5/1114 A61B5/163 A61B5/18 B60K35/00 B60K2370/191 B60K2370/338 B60T2201/022 B60T2201/08 B60T2201/086 B60W40/09 B60W50/14 B60W2040/0827 B60W2540/22 G06K9/00845 G08B21/06		
优先权	60/357135 2002-02-19 US 60/418171 2002-10-15 US		
其他公开文献	EP1478268A4 EP1478268A1		
外部链接	Espacenet		

摘要(译)

本发明涉及一种借助于至少一个碰撞警告系统辅助驾驶员的方法，该方法包括以下步骤：基于驾驶员的头部和/或眼睛运动测量驾驶员的视觉活动;根据测量的视觉活动评估驾驶员对驾驶任务的关注程度;并且将所述至少一个碰撞警告系统的警告阈值调整到所评估的驾驶员的注意力水平。

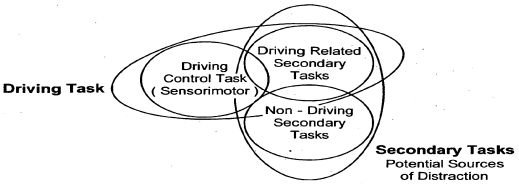

FIG. 1

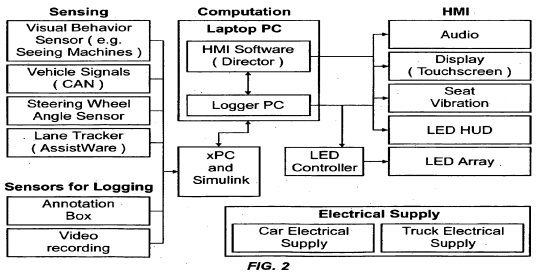

FIG. 2