A VEHICLE OPERATOR SAFETY METHOD AND SYSTEM THEREOF

TECHNICAL FIELD

This disclosure relates to monitoring systems, in particular monitoring systems for use in automotive.

BACKGROUND

Monitoring systems are used in motor vehicles for various reasons, such as driver monitoring for prevention of traffic accidents and for ensuring safety of driver. A common objective of driver monitoring is to determine a state of driver, for example to determine if driver is drowsy or fatigue.

Conventional motor vehicle monitoring systems uses in-vehicle camera for monitoring facial features of a vehicle operator to determine state of driver. However, vehicle operator monitoring using in-vehicle cameras relies on information processing of facial and/or partial body images of the vehicle operator.

In addition, driver's distraction, such as driver on phones or eyes not on the road while driving is often not considered in driver monitoring systems. To achieve the objective of prevention of traffic accidents and ensuring safety of vehicle operator, other factors need to be considered.

The background description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure.

SUMMARY

A purpose of this disclosure is to ameliorate the problem of vehicle operator's safety while driving, by providing the subject-matter of the independent claims.

Further purposes of this disclosure are set out in the accompanying dependent claims.

The objective of this disclosure is solved by a vehicle operator safety method comprising:

acquiring, by way of an imaging module, video sequence images of a vehicle operator;

processing, by way of a processor, video sequence images acquired by the imaging module;

and

determining, by way of the processor, an anomality behaviour of the vehicle operator,

characterized by that:

processing the video sequence images by the processor further comprises:

- identifying an eye open state or eye close state of the vehicle operator;

and

- determining a health status of the vehicle operator.

An advantage of the above-described aspect of this disclosure yields a method of determining an anomality behaviour of a vehicle operator, by using image processing to identify an eye open or eye close state of the vehicle operator with a combination of determining a health status of the vehicle operator to ensure safety of the vehicle operator when operating a motor vehicle. More advantageously, the method disclosed herein uses image processing algorithm to process images captured by an imaging module to determine both eye status and health status of the vehicle operator, thereby reducing the number of hardware components or external devices for determining vehicle operator's health status.

Preferred is a method as described above or as described above as being preferred, in which:

identifying the eye open state or eye close state of the vehicle operator further comprises:

in response to the video sequence images processed by the processor,

determining, by way of a neural network, an eye aspect ratio of the vehicle operator; and

measuring, by way of the neural network, a rate per minute of an open eye lid or a closed eye lid of the vehicle operator.

The advantage of the above aspect of this disclosure is to yield a step of determining an eye aspect ratio of the vehicle operator using a neural network based upon the video sequence images processed, such that a rate per minute of an open eye lid or a closed eye lid of the operator may be determined, to identify an eye open or closed state of the vehicle operator. This parameter helps to identify whether the vehicle operator is blinking or falling asleep using measurement of eye aspect ratio and rate of eye lid opening and closing through image processing.

Preferred is a method as described above or as described above as being preferred, in which:

identifying the eye open state or eye close state of the vehicle operator further comprises:

- recognizing, by way of the neural network, a position of an eye of the vehicle operator from the eye aspect ratio determined;

and

- classifying, by way of the neural network, the eye open state or eye close state of the vehicle operator.

The advantage of the above aspect of this disclosure is to use a neural network to determine a position of an eye of the vehicle operator based upon the video sequence images processed and in response to determining the eye position of the

vehicle operator, classify a state of an eye lid of the vehicle operator is open or close.

Preferred is a method as described above or as described above as being preferred, in which:

determining the health status of the vehicle operator further comprises:

extracting RGB data from the video sequence images acquired by the imaging module with a signal processing algorithm.

The advantage of the above aspect of this disclosure is to extract the RGB channel data for processing signals from video frames segmentized from the video sequence images acquired by the imaging module using a signal processing algorithm.

Preferred is a method as described above or as described above as being preferred, in which:

determining the health status of the vehicle operator further comprises:

in response to the RGB data extracted,

producing, by way of the processor, one or more images containing photoplethysmography signals.

The advantage of the above aspect of this disclosure is to determine the health status of the vehicle operator using the RGB data extracting by the signal processing algorithm to produce images containing photoplethysmography signals, otherwise known as imaging photoplethysmography (i-PPG).

Preferred is a method as described above or as described above as being preferred, in which:

determining the health status of the vehicle operator comprises:

in response to the one or more images containing plethysmography signals produced,

processing, by way of the processor, a physiological information relating to the vehicle operator.

The advantage of the above aspect of this disclosure is to yield a method of using the imaging photoplethysmography (i-PPG) produced from a previous step to process a physiological information relating to the vehicle operator, thus determining a health status of the vehicle operator. An example of a type of physiological information may include optical absorption characteristics of (oxy-) haemoglobin, which may be used to detect heart rate of the vehicle operator.

Preferred is a method as described above or as described above as being preferred, in which:

determining the anomality behaviour of the vehicle operator further comprises:

processing, by way of the processor, a presence of weight on at least an area of a steering wheel.

The advantage of the above aspect of this disclosure is to detect a presence of weight on a steering wheel, which may be attributed by presence of a hand grip on at least one area of the steering wheel, to determine whether the vehicle operator is still operating the motor vehicle, for example presence of one hand or both hands on steering wheel or both hands not on steering wheel. Further, in the event the vehicle operator is having a seizure, a heart attack or falling asleep on the wheels, counter measurements may be triggered. More advantageously, determination of a presence of weight on at least an area of a steering wheel is a feature which may be combined with processing of video sequence images for determination of the eye open or closed status and health status of the vehicle operator, to increase accuracy of predicting drowsiness of vehicle operator, thereby ensure safety of the vehicle operator.

Preferred is a method as described above or as described above as being preferred, in which:

determining the anomality behaviour of the vehicle operator further comprises:

detecting, by way of the processor, a state of abrupt driving behaviour by the vehicle operator.

The advantage of the above aspect of this disclosure is to analyzing potential abrupt driving behaviour by the vehicle operator, for detection of vehicle operator drowsiness. More advantageously, determination of abrupt driving behaviour is a feature which may be combined with processing of video sequence images for determination of the eye open or closed status and health status of the vehicle operator, to increase accuracy of predicting drowsiness of vehicle operator, thereby ensure safety of the vehicle operator.

The objective of this disclosure is solved by a vehicle operator safety system comprising:

an imaging module operable to acquire video sequence images of a vehicle operator;

a processor including a memory operable to process the video sequence images of the vehicle operator acquired by the imaging module,

characterized in that:

the processor is further operable to:

- identify an eye open state or eye close state of the vehicle operator;

and

- determine a health status of the vehicle operator.

An advantage of the above-described aspect of this disclosure yields a system operable to determine an anomality behaviour of a vehicle operator, by using image processing to identify an eye open or eye close state of the vehicle operator with a combination of determining a health status of the vehicle operator to ensure safety of the vehicle operator when operating a motor vehicle. More advantageously, the system disclosed herein uses image processing algorithm to process images captured by an imaging module to determine both eye status and health status of the vehicle operator, thereby reducing the number of hardware components or external devices for determining vehicle operator’s health status.

Preferred is a system as described above or as described above as being preferred, in which:

the processor is further operable to determine an eye aspect ratio of the vehicle operator, wherein the eye aspect ratio is used to measure an open eye lid or a closed eye lid of the vehicle operator in a rate per minute.

The advantage of the above aspect of this disclosure is to yield a system operable to determine an eye aspect ratio of the vehicle operator using a neural network based upon the video sequence images processed, such that a rate per minute of an open eye lid or a closed eye lid of the operator may be determined, to identify an eye open or closed state of the vehicle operator. This parameter helps to identify whether the vehicle operator is blinking or falling asleep using measurement of eye aspect ratio and rate of eye lid opening and closing through image processing.

Preferred is a system as described above or as described above as being preferred, in which:

the processor is operable to

- recognize a position of an eye of the vehicle operator from the eye aspect ratio determined;

and

- classify the eye open state or eye close state of the vehicle operator.

The advantage of the above aspect of this disclosure is to use a neural network to determine a position of an eye of the vehicle operator based upon the video sequence images processed and in response to determining the eye position of the vehicle operator, classify a state of an eye lid of the vehicle operator is open or close.

Preferred is a system as described above or as described above as being preferred, in which:

the health status of the vehicle operator comprises at least one physiological information relative to the vehicle operator.

The advantage of the above aspect of this disclosure is to determine a physiological information of the vehicle operator. In the disclosure herein, the physiological information of the vehicle operator is determined using imaging photoplethysmography (i-PPG) produced from video frames segmentized from video sequence images captured by the imaging module.

Preferred is a system as described above or as described above as being preferred, in which:

the processor is further operable to execute a signal processing algorithm to extract RGB data from the video sequence images acquired by the image module to determine the health status of the vehicle operator.

The advantage of the above aspect of this disclosure is to extract the RGB channel data for processing signals from video frames segmentized from the video sequence images acquired by the imaging module using a signal processing algorithm. Consequently, no additional hardware components or external devices are required to determine health status of the vehicle operator.

Preferred is a system as described above or as described above as being preferred, in which:

in response of the RGB data extracted, the signal processing algorithm is operable to produce one or more images containing photoplethysmography signals.

The advantage of the above aspect of this disclosure is to analyse the images containing photoplethysmography signals produced by the signal processing algorithm to determine physiological information relative to the vehicle operator.

Preferred is a system as described above or as described above as being preferred, in which:

the system further comprises a weight detection device operable to detect a presence of weight.

The advantage of the above aspect of this disclosure is to include a weight detection device operable to detect a presence of weight. The weight detection device may include one or more sensing devices to measure an amount of weight being pressed against.

Preferred is a system as described above or as described above as being preferred, in which:

the weight detection device is embedded within a steering wheel.

The advantage of the above aspect of this disclosure is to embed the weight detection device within a steering wheel of a motor vehicle. More advantageously, the aforesaid configuration is operable to detect a presence of a weight pressed against at least an area of a steering wheel of a motor vehicle, to detect whether there is a hand grip on the steering wheel, to determine if the vehicle operator is still operating the motor vehicle, or perhaps if both hands are not on the steering wheel.

Preferred is a system as described above or as described above as being preferred, in which:

the system further comprises a vehicle lane detection system.

The advantage of the above aspect of this disclosure is to use vehicle lane detection system to observe or analyse a state of abrupt driving behaviour by the vehicle operator. More advantageously, determination of abrupt driving behaviour is a feature which may be combined with processing of video sequence images for determination of the eye open or closed status and health status of the vehicle operator, to increase accuracy of predicting drowsiness of vehicle operator, thereby ensure safety of the vehicle operator.

Preferred is a system as described above or as described above as being preferred, in which:

the processor further comprises a neural network.

The advantage of the above aspect of this disclosure is to utilize a neural network to recognise a position of an eye of the vehicle operator using an eye aspect ratio and to detect open and close state of eye of the vehicle operator based on a rate of opening and closing the eye lid per minute. This improves accuracy of image processing to detect drowsiness or state of fatigue of the vehicle operator.

The objective of this disclosure is solved by a computer program product comprising instructions to cause the system as disclosed above to execute the steps of the method disclosed above.

An advantage of the above described aspect of this disclosure yields a computer program for executing a set of instructions in response to determination of an anomality behaviour of the vehicle operator, of which the determination of the anomality behaviour of the vehicle operator is identified through processing of video sequence images, to identify an eye open state or eye close state of the vehicle operator and to determine a health status of the vehicle operator.

The objective of this disclosure is solved by a computer-readable medium having stored on the computer program as disclosed herein.

An advantage of the above-described aspect of this disclosure yields a computer-readable medium for executing the computer program as disclosed.

Other objects, features and characteristics, as well as the methods of operation and the functions of the related elements of the structure, the combination of parts and economics of manufacture will become more apparent upon consideration of the following detailed description and appended claims with reference to the accompanying drawings, all of which form a part of this specification. It should be understood that the detailed description and specific examples, while indicating the non-limiting embodiments of the disclosure, are intended for purposes of illustration only and are not intended to limit the scope of the disclosure.

BRIEF DESCRIPTION OF DRAWINGS

Other objects and aspects of this disclosure will become apparent form the following description of embodiments with reference to the accompanying drawings in which:

FIG. 1 shows a flowchart illustrating a vehicle operator method.

FIG. 2a shows a flowchart illustrating a process for identifying an eye open state or eye close state of a vehicle operator in accordance with an exemplary embodiment.

FIG. 2b shows a flowchart illustrating a process for determining a health status of a vehicle operator in accordance with an exemplary embodiment.

FIG. 3 shows a block diagram of a vehicle operator system.

FIG. 4a and 4b shows an exemplary embodiment of determining an eye open state or eye close state of a vehicle occupant respectively.

FIG. 5a shows a precision curve (P-curve) of a neural network in accordance with an exemplary embodiment.

FIG. 5b shows a recall curve (R-curve) of a neural network in accordance with an exemplary embodiment.

FIG. 6 shows a video sequence image of a vehicle lane changing system in accordance with an exemplary embodiment.

In various embodiments described by reference to the above figures, like reference signs refer to like components in several perspective views and/or configurations.

DETAILED DESCRIPTION

The following detailed description is merely exemplary in nature and is not intended to limit the disclosure or the application and uses of the disclosure Furthermore, there is no intention to be bound by any theory presented in the preceding background of the disclosure following the detailed description. It is the intent of this disclosure to present a vehicle operator safety method and system which identifies an open eye status or closed eye status of a vehicle operator using a neural network and a health status of the vehicle operator using image processing algorithm, in particular plethysmography method to determine a physiological information of the vehicle operator, to identify the health status.

Hereinafter, the term “processor” may also refer to a “computer” and the term “processor” used herein may broadly encompass a general-purpose processor, a central processing unit (CPU), a microprocessor, a digital signal processor (DSP), a controller, a microcontroller, a state machine, and so forth. Under some circumstances, a "processor" may refer to an application specific integrated circuit (ASIC), a programmable logic device (PLD), a field programmable gate array (FPGA), etc. The term "processor" may refer to a combination of processing devices, for example, a single hardware component or two or more hardware components may be implemented by a single processor, or two or more processors, or a processor and a controller. One or more hardware components may be implemented by one or more processors, or a processor and a controller, and one or more other hardware components may be implemented by one or more other processors, or another processor and another controller. One or more processors, or a processor and a controller, may implement a single hardware component, or two or more hardware components. A hardware component may have any one or more of different processing configurations, examples of which include a single processor, independent processors, parallel processors, single-instruction single-data (SISD) multiprocessing, single-instruction multiple-data (SIMD) multiprocessing, multiple-instruction single-data (MISD) multiprocessing, and multiple-instruction multiple-data (MIMD) multiprocessing. The “processor” may include a memory, for loading a sequence of instruction, causing the “processor” to

perform steps of actions. The term "memory" should be interpreted broadly to encompass any electronic component capable of storing electronic information. The term “memory” may refer to various types of processor-readable media such as random access memory (RAM), read-only memory (ROM), non-volatile random access memory (NVRAM), programmable read-only memory (PROM), erasable programmable read only memory (EPROM), electrically erasable PROM (EEPROM), flash memory, magnetic or optical data storage, registers, etc. “Memory” is said to be in electronic communication with a processor if the processor can read information from and/or write information to the memory. Memory that is integral to a processor is in electronic communication with the processor. Henceforth, the term “processor” may also be taken to encompass “system on chip” (SoC) which uses a single integrated circuit (IC) chip that contains multiple resources, computational units, processors and/or cores integrated on a single substrate. A single SOC may contain circuitry for digital, analog, mixed-signal, and radio-frequency functions, as well as any number of general purpose and/or specialized processors (digital signal processors, modem processors, video processors, etc.), memory blocks (e.g., ROM, RAM, Flash, etc.). Unless otherwise specifically stated, the “processor” is not limited to any specific combination of hardware circuitry and software, nor to any particular source for the instructions executed by the processing unit. For simplicity, the singular term “processor” or “computer” may be used in the description of the examples described in this disclosure, but in other examples multiple processors or computers may be used, or a processor or computer may include multiple processing elements, or multiple types of processing elements, or both.

Referring now to the drawings, FIG. 1 shows a flowchart 100 illustrating a vehicle operator safety method. At step 102, video sequence images of a vehicle operator are acquired by an imaging module, while the vehicle operator is operating a motor vehicle. At step 104, the video sequence images acquired from previous step 104 are processed and segmentized into video frames and at step 106, determination of an anomality behaviour of the vehicle operator is determined through image processing of the video frames segmentized from step 104.

An anomality behaviour of the vehicle operator is determined by identifying an eye open or closed state of the vehicle operator at step 108 and determining a health status of the vehicle operator at step 110. In an embodiment, step 108 and step 110 are processed concurrently. In another embodiment, step 108 is processed first, followed by step 110.

Preferably, in response to an anomality behaviour identified from step 108 and step 110, in a next step 126, a presence of weight on a weight detection device is processed. The weight detection device may be embedded within a steering wheel of a motor vehicle, of which the presence of weight may be from the vehicle operator's engagement with the steering wheel, for example, at least one hand grip on an area of the steering wheel, no presence of hand grip on the steering wheel or presence of hand grip on two area of the steering wheel. In the event the vehicle operator collapses on the steering wheel, the weight detection device is operable to detect a weight of the vehicle operator's body on the steering wheel.
Preferably, at step 128, video images acquired by a vehicle lane changing system are analysed to observe abrupt driving behaviour.

A main advantage of this disclosure is the use of image processing techniques for identifying an eye open or eye close state of the vehicle operator and determining a health status of the vehicle operator, to determine an anomality behaviour of a vehicle operator. More advantageously, the benefit of the method and system disclosed herein uses a combination of different image processing techniques to process video sequence images such that different types of information may be processed and analysed from the video sequence images acquired by an imaging module. Consequently, the benefit of using image processing techniques eliminates the requirement of additional hardware components or external devices such as sensing devices or wearable devices to determine health status of the vehicle operator.

Eye Detection Process 200a

FIG. 2a shows a flowchart illustrating a process 200a for identifying an eye open state or eye close state of a vehicle operator in accordance with an exemplary embodiment of this disclosure.

In this disclosure, the steps for identifying an eye open state or eye close state of a vehicle operator uses an artificial neural network to process video frames acquired of the vehicle operator to determine drowsiness, multi-tasking or distraction of the vehicle operator while driving. A suitable type of artificial neural network may be convolution neural network (CNN) but not limited thereto. An advantage of using a CNN architecture for image processing is the use of object detection, which may be trained on large dataset for eye detection from a facial image.

The process 202 includes at step 112, determining an eye aspect ratio of the vehicle operator using video frames segmentized from video sequence images of the vehicle operator.

At step 114, a rate per minute of an open eye lid or closed eye lid of the vehicle operator is measured. An advantage of a rate per minute is for further processing, to detect eye blinking rate, to determine a state of drowsiness of the vehicle operator.

At step 116, a position of an eye of the vehicle operator is recognised from a facial image contained in the video frame segmentized from the video sequence images and in a next step 118, an eye open state or an eye close state of the vehicle operator is classified according to respective categories, namely a first category where an eye lid is recognised as open and a second category where an eye lid is recognised as closed. Both step 116 and step 118 are carried out by a neural network, for facial image recognition and classification of an eye lid opened or an eye lid closed status.

Health Status Determination 200b

FIG. 2b shows a flowchart 200b illustrating a process for determining a health status of a vehicle operator in accordance with an exemplary embodiment.

In this disclosure, the steps for determining a health status of the vehicle operator uses imaging photoplethysmography (i-PPG) to derive heart rate of the vehicle operator. A main advantage of using imaging photoplethysmography (i-PPG) to derive heart rate is the elimination of additional hardware within an interior of a motor vehicle, to determine health status of the vehicle operator. By way of example, vital signs may be monitored using complex cameras that are able to capture images in far-infrared (FIR) or near-infrared (NIR) wavelengths. Other known method may include embedding sensing devices within an interior of a motor vehicle to measure health signals related to the vehicle operator. Both types of method require further image or signal processing to obtain the right source of vital signs and such additional hardware increase costs. Another known method is to use health data collected from wearables worn by the vehicle operator to determine vital signs of the vehicle operator. By using imaging photoplethysmography (i-PPG), physiological information can be derived from segmentized video images acquired by imaging module within an interior of a cabin of a passenger car. A suitable type of imaging module may be available in driver monitoring system or cabin monitoring system. In other words, convention onboard or in-vehicle camera will be operable to capture such video sequence images.

There is very subtle difference between a state of drowsiness and a state of dizziness. However, heart rate detection may be used to differentiate between a state of drowsiness and a state of dizziness. A state of dizziness is often caused by blood pressure abnormalities or any other health issues and physiological data can be estimated through optical absorption characteristics of (oxy-) hemoglobin. Another advantage of using imaging photoplethysmography (i-PPG) to derive heart rate as presented in this disclosure is that determination of a stable heartbeat can be isolated in as fast as 15 seconds.

Referring to FIG. 2b, after executing the step of 110 for determination of a health status of the vehicle operator, at step 120, RGB data is extracted from video sequence images acquired by an image module using signal processing algorithm, to produce one or more images containing photoplethysmography signals in a next

step 122. A suitable signal processing algorithm may be photoplethysmography method. In a next step 124, the one or more images containing photoplethysmography signals are further processed to obtain a physiological information relating to the vehicle operator.

In a preferred embodiment, both step 108 and 110 may be executed concurrently. In another preferred embodiment, step 110 for determining a health status of the vehicle operator may be executed in response to step 108 for identifying an eye open state or an eye close state, where the vehicle operator is determined to be in a state of drowsiness.

In both embodiments as explained above and referring to FIG. 1, the method 100 may further execute step 126 for determining a presence of weight on at least an area of the steering wheel.

In addition to the identifying of an eye open state or an eye close state at step 108 and determination of a health status of the vehicle operator, the step of 126 provides additional analysis for determining whether there is:

- presence of a weight on at least an area of the steering wheel indicating presence of at least one hand grip on the steering wheel of the motor vehicle;
- presence of a weight on at least two areas of the steering wheel indicating presence of both hands on the steering wheel of the motor vehicle;
- no presence of weight on at least an area of the steering wheel indicating both hands are off the steering wheel of the motor vehicle; or
- excessive weight detected on the steering wheel of the motor vehicle, indicating head or body of the vehicle operator on the steering wheel.

Preferably, in the event that no presence of weight is detected on the steering wheel, or excessive weight is detected on the steering wheel, the method 100 further processes and detect whether there is a state of abrupt driving behaviour by the vehicle operator at step 128.

System Block Diagram 300

FIG. 3 shows a block diagram of a vehicle operator safety system 300.

The vehicle operator safety system 300 includes an imaging module 302, a processor 304. The processor 304 includes a memory having a first set of instructions stored thereon, to execute an eye detection process 306 (Step 108 of FIG. 1 referred) to identify an eye open state or an eye close state of the vehicle occupant (FIG. 2a referred), and a second set of instructions stored thereon, to execute a health status analyser process 308 (Step 110 of FIG. 1 referred) to determine a health status (FIG. 2b referred) of the vehicle occupant.

The vehicle operator safety system 300 further includes a weight detection device 310 operable to detect a presence of an amount of weight. The weight detection device 310 includes at least one sensing device to detect the presence of weight and the detection device 310 is embedded in a steering wheel. A suitable type of sensing device may be a capacitive sensor although not limited thereto and it shall be apparent to a skilled practitioner other types of sensing device operable to detect a presence of weight may be use as a variant.

Further thereto, the system 300 includes a vehicle lane detection system 312 to detect whether there is a state of abrupt driving behaviour by the vehicle operator. The vehicle lane detection system 312 is a computer vision algorithm which receives raw RGB images acquired by an external imaging module mounted external to the motor vehicle, to produce lane-line segments that represent the boundary of the road for the motor vehicle. Example of an external imaging module may be a surround view camera operable to acquire video images surrounding the motor vehicle, or a dash-cam operable to acquire video images in front of the motor vehicle, and the vehicle lane detection system 312 is evaluated using actual road images acquired.

As explained above, in addition to the identification of an eye open state or an eye close state at step 108 and determination of a health status of the vehicle operator,

the presence of a weight on the steering wheel may be an auxiliary parameter to determine a safety of the vehicle operator, as an indication of:

- presence of a weight on at least an area of the steering wheel indicating presence of at least one hand grip on the steering wheel of the motor vehicle;
- presence of a weight on at least two areas of the steering wheel indicating presence of both hands on the steering wheel of the motor vehicle;
- no presence of weight on at least an area of the steering wheel indicating both hands are off the steering wheel of the motor vehicle; or
- excessive weight detected on the steering wheel of the motor vehicle, indicating head or body of the vehicle operator on the steering wheel.

Optionally, the system 300 may include a warning system 314, which receives a notification from the processor 304 in response to identifying an eye close status of the vehicle operator and determining the health status of the vehicle operator indicates he/she is unfit for operating the motor vehicle. In response to the notification received from the processor 304, the warning system 314 may trigger assistance for medical help or automate autonomous driving function to ensure safety of the driver.

In all of the above embodiments disclosed herein, the processor 304 may include a neural network suitable for image processing, to recognise an eye position and classify an eye open state or eye close state of the vehicle operator. A suitable type of neural network may be a convolutional neural network (CNN). For clarity and brevity, the use of CNN to execute machine learning or artificial intelligence algorithms may be better understood from the paper “Understanding of a convolutional neural network” published in 2017 International Conference on Engineering and Technology, IEEE. It shall be further understood by a skilled practitioner, other types of neural network suitable for object detection and object classification, for example region-based convolutional neural network (R-CNN), or Fast R-CNN may also be suitable, but not limited thereto.

In all of the above embodiments disclosed herein, the processor 304 may be an artificial intelligence processing unit also known as AI PU or an AI chip, an AI SoC specifically fabricated to execute machine learning algorithms, typically by operating on predictive models such as artificial neural networks. They are usually classified as either training or inference as these processes are generally performed independently.

In all of the above embodiments disclosed herein, the transmission of processed data between different hardware elements may be in the form of wired or wireless communication, of which the transmission of recommendation content may be in the form of a signal carrying information data of the recommendation content.

RGB Data Extraction

FIG. 4a and 4b shows an exemplary embodiment of determining an eye close state video frame 400a and an eye open state video frame 400b of a vehicle occupant respectively. Referring to FIG. 4a, a RGB splitter 402 is placed on a forehead of the vehicle operator in the eye close state video frame 400a, to extract data from the RGB channel. This extracted RGB data is then processed using signal processing algorithm, to produce images containing photoplethysmography signals by plethysmography method. The eye lid closed or eye lid open classification (i.e. step 118 of flowchart 100) as explained above may be executed and detected in parallel and images yield may be compared to detect a state of drowsiness of the vehicle operator.

Training Neural Network Model

In an exemplary embodiment using CNN architecture, object detection based on YOLOv5 (You Only Look Once) algorithm may be applied to train on large data set for detection of eye position from a facial image. As explained above, this may be acquired from images captured by cameras, for example video sequence images, and the images may be segmentized and classified eyelid state into a first category where an eye lid is recognised as open eye status and a second category where an eye lid is recognised as close eye status. It shall be understood by a person skilled

in the art, other suitable neural network designed for object detection and object classification may be suitable architecture.

FIG. 5a shows a precision curve (P-curve) 500a of a neural network in accordance with an exemplary embodiment, while FIG. 5b shows a recall curve (R-curve) 500b of a neural network in accordance with an exemplary embodiment.

Using the example of CNN architecture, the proposed neural network model after training yields 96.3% precision as shown in P-curve 500a and 98.4% recall on the validation dataset as shown in recall curve R-curve 500b indicating the use of a trained CNN model yields improved accuracy in identifying an eye open state or an eye closed state of the vehicle operator over existing known solutions for driver monitoring functions.

Vehicle Lane Detection Process

FIG. 6 shows a video sequence image 600 of a vehicle lane changing system in accordance with an exemplary embodiment. As shown in video sequence image 600, an image of the lane 602 which the motor vehicle is travelling along is acquired in a real time video sequence image. Such video images may be captured by image module, such as a dashcam, operable to capture a field of view in front of the motor vehicle. A suitable type of technique for vehicle lane detection process may be computer vision algorithms. The process may include determining areas of interest using segmentized video sequence images and appropriate algorithm to create lane-line segments that represents lane boundary for the motor vehicle, to determine vehicle movement within the lane boundary. In the event the motor vehicle shows abrupt vehicle movement towards a left side of the lane represented by dotted line 604 or right side of the lane represented by solid line 606, the vehicle lane changing system processes such vehicle movement, a rate of how often such vehicle movement occurs and determine if the vehicle operator is driving in an abrupt manner.

The foregoing description shall be interpreted as illustrative and not be limited thereto. One of ordinary skill in the art would understand that certain modifications

may come within the scope of this disclosure. Although the different non-limiting embodiments are illustrated as having specific components or steps, the embodiments of this disclosure are not limited to those combinations. Some of the components or features from any of the non-limiting embodiments may be used in combination with features or components from any of the other non-limiting embodiments. For these reasons, the appended claims should be studied to determine the true scope and content of this disclosure.

List of Reference Signs

100	Flowchart
102	Acquire video sequence images
104	Processing video sequence images
106	Determining anomality behavior
108	Identifying an eye open or close state
110	Determining health status of vehicle operator
112	Determining an eye aspect ratio of the vehicle operator
114	Measuring a rater per min of open eye lid or closed eye lid
116	Recognizing a position of the eye of the vehicle operator
118	Classifying the eye open state or eye close state of the vehicle operator
120	Extracting RGB data from video sequence images
122	Producing one or more images containing photoplethysmography signals
124	Process physiological information from plethysmography images
126	Processing presence of weight
128	Detecting a state of abrupt driving behavior
200a	Eye detection process
200b	Health status detection process
300	system
302	Imaging module
304	processor
306	Eye detection algorithm to detect eye open / close state
308	Health analyzer algorithm to detect health status
310	Weight detection device
312	Vehicle lane detection system
314	Warning system
400a	Eye closed video frame
402	Forehead RGB splitter to extract RGB data
404	Eye position
400b	Eye open video frame
406	Eye aspect ratio
500a	Recall curve (R-curve)
500b	Precision curve (P-curve)
600	Video sequence image processing algorithm of a vehicle lane detection system
602	Lane
604	a left side of the lane represented by dotted line

606 Right side of the lane represented by solid line

Patent claims

1. A vehicle operator safety method comprising:

acquiring, by way of an imaging module, video sequence images of a vehicle operator;

processing, by way of a processor, video sequence images acquired by the imaging module;

and

determining, by way of the processor, an anomality behaviour of the vehicle operator,

characterized by that:

processing the video sequence images by the processor further comprises:

- identifying an eye open state or eye close state of the vehicle operator;

and

- determining a health status of the vehicle operator.

2. The method according to claim 1, characterized by that identifying the eye open state or eye close state of the vehicle operator further comprises:

in response to the video sequence images processed by the processor,

determining, by way of a neural network, an eye aspect ratio of the vehicle operator; and

measuring, by way of the neural network, a rate per minute of an open eye lid or a closed eye lid of the vehicle operator.

3. The method according to claims 1 – 2, characterized by identifying the eye open state or eye close state of the vehicle operator further comprises:

- recognizing, by way of the neural network, a position of an eye of the vehicle operator from the eye aspect ratio determined;

and

- classifying, by way of the neural network, the eye open state or eye close state of the vehicle operator.

4. The method according to claim 1 – 3, characterized by that determining the health status of the vehicle operator further comprises:

extracting RGB data from the video sequence images acquired by the imaging module with a signal processing algorithm.

5. The method according to claim 4, characterized by that determining the health status of the vehicle operator further comprises:

in response to the RGB data extracted,

producing, by way of the processor, one or more images containing photoplethysmography signals.

6. The method according to claims 1 – 5, characterized by that determining the health status of the vehicle operator comprises:

in response to the one or more images containing plethysmography signals produced,

processing, by way of the processor, a physiological information relating to the vehicle operator.

7. The method according to claims 1-6, characterized by that determining the anomality behaviour of the vehicle operator further comprises:

processing, by way of the processor, a presence of weight on at least an area of a steering wheel.

8. The method according to claims 1-7, characterized by that determining the anomality behaviour of the vehicle operator further comprises:

detecting, by way of the processor, a state of abrupt driving behaviour by the vehicle operator.

9. A vehicle operator safety system comprising:

an imaging module operable to acquire video sequence images of a vehicle operator;

a processor including a memory operable to process the video sequence images of the vehicle operator acquired by the imaging module, **characterized in that:**

the processor is further operable to:

- identify an eye open state or eye close state of the vehicle operator;

and

- determine a health status of the vehicle operator.

10. The system according to claim 9, characterized in that the processor is further operable to determine an eye aspect ratio of the vehicle operator, wherein the eye aspect ratio is used to measure an open eye lid or a closed eye lid of the vehicle operator in a rate per minute.

11. The system according to claim 9-10, characterized in that the processor is operable to

- recognize a position of an eye of the vehicle operator from the eye aspect ratio determined;

and

- classify the eye open state or eye close state of the vehicle operator.

12. The system according to claims 9-11, characterized in that the health status of the vehicle operator comprises at least one physiological information relative to the vehicle operator.

13. The system according to claims 9-12, characterized in that processor is further operable to execute a signal processing algorithm to extract RGB data from the video sequence images acquired by the image module to determine the health status of the vehicle operator.

14. The system according to claims 9 – 13, characterized in that in response to the RGB data extracted, the signal processing algorithm is operable to produce one or more images containing photoplethysmography signals.

15. The system according to claim 10-14, characterized in that the system further comprises a weight detection device operable to detect a presence of weight.

16. The system according to claim 16, characterized in that the weight detection device is embedded within a steering wheel.

17. The system according to claims 9-16, characterized in that the system further comprises a vehicle lane detection system.

18. The system according to any one of the preceding claims, characterized by that the processor further comprises a neural network.

19. A computer program comprising instructions to cause the system of claims 9 to 18 to execute the steps of the methods of claims 1 – 8.

20. A computer-readable medium having stored thereon the computer program product of claim 19.

Abstract

A VEHICLE OPERATOR SAFETY METHOD AND SYSTEM THEREOF

Disclosure is a vehicle operator safety method comprising acquiring, by way of an imaging module, video sequence images of a vehicle operator; processing, by way of a processor, video sequence images acquired by the imaging module; and determining, by way of the processor, an anomality behaviour of the vehicle operator, wherein processing of the video sequence images comprises identifying an eye open state or eye close state of the vehicle operator using a neural network and determining a health status of the vehicle operator using plethysmography method, to determine a physiological information. A system, a computer program product and a computer readable medium for the same is also disclosed.

FIG. 1