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(54) Title: A LIGHT MONITORING SYSTEM, A GLARE PREVENTION SYSTEM, A VEHICLE AND A METHOD OF MONITORING GLARE

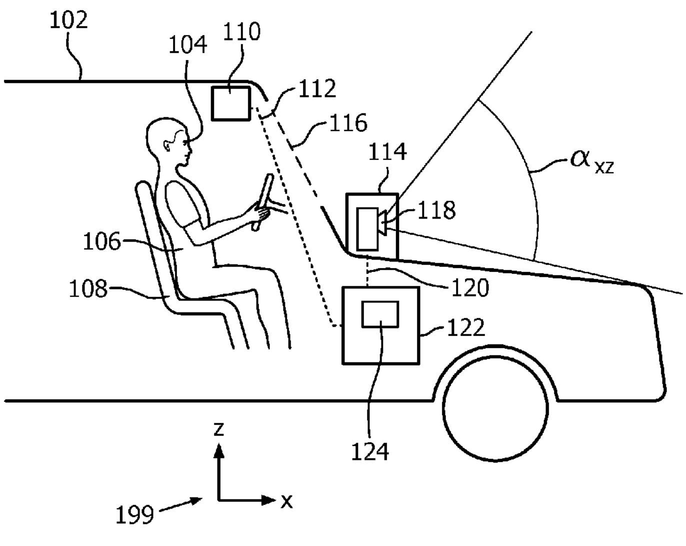

FIG. 1a

(57) Abstract: A light monitoring system, a glare prevention system, a method of monitoring glare and a vehicle 102 are provided. The light monitoring system comprises a camera system 114, a user's eye tracker 110 and an incident light calculator 124. The camera system 114 records at a camera location incident light from a light source. The user's eye tracker 110 determines a position of the user's eyes104. The incident light calculator 124 calculates perceived incident light by the user's eyes 104 and transforms the recorded incident light at the camera location into the perceived incident light at the position of the user's eyes. The perceived incident light may be used to estimate whether the user 106 perceives glare and this information may be used to control a dynamic light intensity filter such that the light originating from a too bright light source is dimmed.

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A LIGHT MONITORING SYSTEM, A GLARE PREVENTION SYSTEM, A VEHICLE AND A METHOD OF MONITORING GLARE

Field of the invention

The invention relates to a light monitoring system for use with or in an item comprising a transparent window through which light is transmitted towards eyes of a user, a glare prevention system for use with or in an item comprising a transparent window through which light is transmitted towards eyes of a user and a vehicle which comprises such a system.

The invention further relates to a method of monitoring glare.

Background of the invention

Glare is a phenomenon wherein a human has difficulties to see because of a very bright light. The very bright light is often received in a light beam (which might be relatively small) and the reception of such a light beam results in either discomfort or difficulties in seeing. Especially in daily traffic glare may cause discomfort to drivers or may result in dangerous situations. Glare is often caused by oncoming traffic during the night and the sun is the largest cause of the perception of glare by drivers of vehicles during the day.

Published patent application US2009/0168185A1 discloses a glare prevention system for use in a car. The system comprises a first and second camera arranged at different positions near the windshield, a third and fourth camera being arranged inside the car, a plurality of electrochromic pixels arranged on the windshield and a processor. The first camera and second camera record images, in a forward driving direction of the car. The third and fourth camera records images of the driver's seat. The processor determines on basis of the recordings of the first and second camera whether too high intensities of light are received from predetermined directions. The processor further determines the position of the eyes of the driver on basis of the recordings of the third and fourth camera. On basis of the above discussed information, the processor calculates the line-of-sight between one or more sources of the too high intensities of light and the eyes of the driver. The position where the calculated line-of-sight intersects the windshield is calculated and the processor controls an opacity of the one or more electrochromic pixels at this calculated position.

The above discussed patent application determines on basis of recordings taken at different positions near the windshield whether received light beams may cause glare. This is relatively inaccurate because the driver is located at another position and the eyes of the driver may perceive these light intensities as more intense or less intense at the position of the driver's eyes. Thus, the system of the above cited patent application may result in too many and/or too less changes of the opacity of electrochromic pixels on the windshield. This is unsafe because either the driver does not have a good view into a specific direction or the driver is blinded by a too intense light source.

US patent US7970172 tries to solve the above problem with a solution wherein only one camera is used which records the head of the driver and uses the information in these recordings to determine whether the driver perceives glare. In an example reflections of light in the eyes of the user are determined and analyzed to determine whether the user receive light from a light source with a too high light intensity. This solution is also relatively inaccurate because the system determines on basis of reflected light whether the user perceives glare. The eye color of the driver influences the reflections and, for example, the use of sun-glasses disturbs the operation of the system.

Summary of the invention

It is an object of the invention to provide a light monitoring system which is more accurate than the known light monitoring systems. Such a light monitoring system must be suitable to be used with or in an item comprising a transparent window through which light is transmitted towards eyes of a user. Such item is, for example, a vehicle.

A first aspect of the invention provides a light monitoring system. A second aspect of the invention provides a glare prevention system. A third aspect of the invention provides a vehicle. A fourth aspect of the invention provides a method of monitoring glare. Advantageous embodiments are defined in the dependent claims.

A light monitoring system in accordance with the first aspect of the invention comprises a camera system, a user's eyes tracker and an incident light calculator. The light monitoring system is suitable to be used with or in an item that comprises an at least partially transparent window through which light is transmitted towards eyes of a user. The camera system records incident light from a light source. The camera system is configured to record, from a camera location, light intensities from the light source. The user's eyes tracker determines a position of the user's eyes. The incident light calculator is for calculating perceived incident light by the user's eyes. The incident light calculator transforms the recorded incident light intensities received at the camera location (Pc) into the perceived incident light intensities at the position of the user's eyes (as perceived by the user's eyes).

Thus, the light monitoring system according to the first aspect of the invention transforms the recorded light intensity into a perceived light intensity such that, with a high probability, it is known what light intensities are received by the user's eyes. This is much more reliable than the known systems because i) not the light intensities measured at another location than the user's eyes location are used to determine whether a user perceives glare, but the perceived light intensities received at the user's eyes are calculated and might be used to monitor whether the user perceives glare; ii) not the reflected light by the eyes or the head of the user are used, but the light intensities directly received at the camera location are used to determine the perceived light intensities. Thus, the information on which it is estimated whether the user perceives glare is based on more reliable information and, thus, a better estimation of perceived glare can be made.

The incident light calculator may apply well-known geometrical and optical formulas to calculate from which direction light beams are received at the user's eyes and what is the light intensity of these beams. Parameters of and results obtained by the camera system and the user's eyes tracker provide enough information to apply these formulas. The camera location is e.g. a fixed parameter and may be programmed in the incident light calculator. Alternatively, the camera is capable to determine its own position (e.g. with a GPS module) and provides its position together with the recorded images to the incident light calculator. The main function of the user's eyes tracker is to determine the position of the user's eyes and, as such, this information is provided by the user's eyes tracker to the incident light calculator. Known eye tracking systems may be used for this purpose.

It is to be noted that the light monitoring system according to the invention may be used in all sorts of vehicles, such as cars, trucks, trains, aircrafts, etc. The light monitoring system may further be used, in, for example, spectacles or goggles.

Optionally, the camera system is configured to determine for the recorded light intensities their angles of incidence and to estimate a distance to the light source. The incident light calculator calculates the perceived incident light on basis of the angles of incidence of the recorded light intensities, the camera location, the position of the user's eyes and the estimated distance between the camera system and the light source. The information mentioned in this optional embodiment is enough to reliable transform the recorded incident light into the perceived incident light.

The camera system determines for the recorded light intensities their angles of incidence. This information can be directly obtained from the position of, for example, an image sensor at which the recorded light intensities impinge and characteristics of an optical system of the camera system.

The camera system determines a distance to the light source which emits the received light intensities and the incident light calculator might use the determined distance in the transforming of the recorded incident light into perceived incident light by the user's eyes. In a practical embodiment, a distance to the light source which emits a relatively high light intensity is determined. The camera system may use specific hardware for determining the distance(s) such as, for example, a means which transmits light waves or audio waves to the objects / light sources of which the distance must be recognized and on basis of the time that the light waves or audio waves require to travel from the camera system to the objects / light sources and back, the distance is determined. Modern photographic cameras comprise hardware to measure the distance and such means may be used by the camera system. Alternatively, the camera system may comprise a 3D camera which comprises two cameras located at slightly different positions. A difference of the angles of incidence of light rays originating from a specific light source at the two cameras is used to calculate the distance of the source of the light rays. The camera system is capable of distinguishing different light intensities received from different angles of incidence. Varying light intensities that are received from different angles of incidence indicate that different light source emit light towards the camera system. As such, the camera system is able to distinguish different light source. Optionally, the camera system is configured to estimate a distance to a light source from which light in at a specific angle of incidence is received. A 3D camera is able to estimate for all imaged object (and, thus, light sources) at which distance they are located with respect to the camera system.

Optionally, the light monitoring system further comprises a perceived glare estimator. The perceived glare estimator estimates whether the user perceives glare. The perceived glare estimator comprises the incident light calculator.

Optionally, the camera system records incident light form the light source within a recording angle and the recording angle is, in use, directed into a direction in which the user, in normal use, looks. For a vehicle this means that the recording angle is directed into the forward driving direction of the car. For spectacles or goggles it means that the recording angle is directed in the viewing direction of the user. However, in other embodiments it might be that the recording angle is very wide, e.g. 360 degrees, and when the light monitoring system is used in combination with a vehicle, that light rays which are received at the back of the vehicle (e.g. from a vehicle that is behind the vehicle with the light monitoring system) are recorded as well. The perceived glare estimator might have knowledge about mirrors in and on the vehicle (such as size, position, reflection direction, etc.) such that perceive glare via, for example, the driving mirror is estimated as well.

Optionally, the camera system comprises a wide-angle camera wherein the recording angle is wider than 120 degrees. A user may receive light from a wide range of angles of incidence because the human eyes have a relatively wide viewing angle and because the user is able to turn his head. Therefore, the camera system may have a wide-angle camera. The recording angle may be wider than 120 degrees, for example, 150 degrees, or 170 degrees. It is to be noted that the recording angle is not necessary in all dimensions this wide, but is at least in one dimension relatively wide. For example, seen along a plane which is parallel to the surface on which, in use, the vehicle drives the recording angle is wider than 120 degrees.

Optionally, the incident light calculator further takes into account a difference between the recording angle of the camera and the angle in which the human eye receives light. The user's eyes tracker may also determine the direction in which the user looks. The incident light calculator, for example, is able to ignore light intensities received at the camera system which, after calculating the angle of incidence at the user's eyes position, fall outside the angle in which the human eye receives light. The user looks into a certain direction and this information may also be used to separate light beams received within the recording angle of the camera into light beams that fall within the angle in which the human eyes receive light from light beams which fall outside this angle (when they are received at the user's eyes).

Optionally, the camera system comprises a plurality of cameras which together form a virtual wide-angle camera. Each one of the plurality of cameras records received light beams in a specific sub-range of the recording angle.

Optionally, the light monitoring system is used in a vehicle which comprises a windshield and the camera location is near the windshield of the vehicle. Most glare that users of a vehicle perceive is received from the front of the car and the received light is transmitted through the windshield. Thus, a good position to reliable record data with respect to light which results in the perception of glare by the user is close to the windshield.

Optionally, the perceived glare estimator is configured to transform angles of incidence of light rays and light beams at the camera into angles of incidence at the position of the user's eyes. Optionally, the perceived glare estimator is configured to transform light intensities as they are received at the camera location (received from given angles of incidence) into light intensities at the position of the user’s eyes. If the angles of incidence and the received light intensities are transformed towards received light at the position of the user’s eyes, a reliable estimation of glare can be made.

Optionally, when the light monitoring system is used in a vehicle, the user’s eyes tracker comprises a further camera which is, in use, directed towards the driver’s seat. The advantage of the use of a camera which is directed towards the eyes of the user is that the user is not bothered with sensors or means to determine the position of his eyes. For example, in specific embodiments, the eye’s tracker may comprises a set of glasses with sensors to determine the position of the user’s eyes, however, such glasses must be worn by the user to be effective and, in such situations, the further camera is not a device to be worn - this may be experienced by users as an advantage. If the further camera is directed towards the driver’s seat, user’s eyes may be recorded in images independently of the length of the user. Thus, the further camera may also record outside the expected area for the user’s eyes of an average length user such that the eyes of relatively small or relatively long users may be tracked as well.

Optionally, the user’s eyes tracker comprises a video recognition system which receives images from the further camera and which is configured to detect in the received images the position of the user’s eyes. Such video recognition systems may accurately estimate the position of the user’s eyes.

Even more accurate position of eyes may be obtained when, for example, a three dimensional camera (comprising, for example, two image sensors which obtain a recorded image from a slightly different position) is used. Other means which estimate the distance from the further camera towards the imaged object (the user) may be used as well for estimating the position of the user’s eyes.

Optionally, the perceived glare estimator is configured to determine whether the perceived incident light exceeds a glare threshold value and the perceived glare estimator is also configured to generate a glare signal when it has been determined that the perceived incident light exceeds the glare threshold value. Thus, the glare signal may be used to warn or control other systems of the car such that, for example, the received light intensities may be dimmed. The glare threshold value may be a predetermine value, however, in other embodiments, the glare threshold value is a dynamic value which relates, for example, to the average light intensity received by the user. The light monitoring system may optionally comprise an average light intensity sensor for measuring the actual average light intensity conditions. When, for example, the average light intensity received by the eyes of the user are relatively high, the diameter of the pupil is relatively small and higher intensities of light must be received before a person experiences glare.

Optionally, the glare estimator is also configured to determine whether incident light received at an estimates angle of incidence at the position of the user's eyes exceeds the glare threshold value and the glare signal also indicates the estimated angle of incidence. In other words, the glare estimator determines the direction from which the (too) high intensity of light comes from (at the position of the user's eyes) and this information is provided in the glare signal such that, for example, other systems in, for example, a vehicle may accurately reduce the intensities of light received from specific directions.

According to a second aspect of the invention, a glare prevention system is provided for use with or in an item comprising a transparent window through which light is transmitted towards eyes of a user. The glare prevention system comprises the light monitoring system according to the first aspect of the invention. The glare prevention system further comprises a dynamic light intensity filter which is, in use, arranged in between the light source which might cause glare and the position of the eyes of the user and the dynamic light intensity filter is arranged to reduce a light intensity transmitted through the dynamic light intensity filter in response to a dimming signal. The glare prevention system is configured to at least partially reduce the glare perceived by the user by reducing the light intensity transmitted through the dynamic light intensity filter when the light monitoring system determines that the user experiences glare. The glare prevention system comprises, for example, a controller which receives input from the light monitoring system (e.g. from the perceived glare estimator) and which generates the dimming signal when the light monitoring system determines that the user perceives glare. Such a controller may be a separate piece of hardware, but may also be combined with the perceived glare estimator of the light monitoring system. It is further to be noted that reducing the light intensity transmitted through the dynamic light intensity filter may comprise reducing the transmitted light along the whole visible spectrum and, alternatively, may comprise reducing the transmission of certain colors to reduce the overall transmitted light intensity.

Optionally, when the glare prevention system comprises the perceived glare estimator, the dynamic light intensity filter is configured to locally reduce a light intensity transmitting through a portion of the dynamic light intensity filter in response to the dimming signal which indicates which portion of the dynamic filter must reduce the light intensity transmitted through the portion. The perceived glare estimator is configured to estimate through which portion of the dynamic light intensity filter the light that is perceived as glare by the user is transmitted. The perceived glare estimator is also configured to generate the dimming signal indicating the portion. In the generation of the dimming signal that indicates the portion, a position of the dynamic light intensity filter with respect to the position of the user's eyes and the camera location is taken into account. This optional embodiment allows the reduction of light transmitted through portion of the dynamic light intensity filter in order to reduce glare and, simultaneously, prevents that too many portions of the dynamic light intensity filter are dimmed. More in particular, this optional embodiment provides a clear view to sections of the environment that do not comprise a very bright light source, while a view towards other sections that comprise very bright light sources is filtered such that less glare is effectively prevented. It is to be noted that other components of the glare prevention system may also estimate the location at which the light rays intercept with the windshield.

According to a third aspect of the invention, a vehicle is provide which comprises the light monitoring system according to the first aspect of the invention or which comprise the glare prevention system according to the second aspect of the invention.

The vehicle according to the third aspect of the invention provides the same benefits as the light monitoring system and the glare prevent system according to, respectively, the first aspect and the second aspect of the invention and has similar embodiments with similar effects as the corresponding embodiments of the systems.

According to a fourth aspect of the invention, a method of monitoring glare. The method comprises the stages of: i) recording from a camera location light intensities received from a light source, ii) determining a position of the user's eyes, iii) transforming the recorded incident light into perceived incident light at the position of the user's eyes

The method according to the further aspect of the invention provides the same benefits as the glare estimation system according to the first aspect of the invention and the glare prevention system according to the second aspect of the invention and has similar embodiments with similar effects as the corresponding embodiments of the systems.

Optionally, the method further comprises the stage of estimating on basis of the perceived incident light at the position of the user's eyes whether the user perceives glare.

A computer program comprising instructions for causing a processor system to perform a subset of the steps the method according to the fourth aspect of the invention is provided and the computer program may be embodied on a computer readable medium.

These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described hereinafter.

It will be appreciated by those skilled in the art that two or more of the above-mentioned options, implementations, and/or aspects of the invention may be combined in any way deemed useful.

Modifications and variations of the system, the vehicle, the method, and/or of the computer program product, which correspond to the described modifications and variations of the system, can be carried out by a person skilled in the art on the basis of the present description.

Brief description of the drawings

In the drawings:

Fig. 1a schematically shows a portion of a car with a light monitoring system,

Fig. 1b schematically shows a pair of spectacles provided with the light monitoring system,

Fig. 2a schematically shows the portion of the car with light rays received from the sun,

Fig. 2b schematically shows a top view of the portion of the car with a light source of an oncoming vehicle,

Fig. 3 schematically shows a 3d model of the different locations of the camera system, the eyes of the driver and the location of the light source,

Fig. 4 schematically shows a glare prevention system comprising a light monitoring system,

Fig. 5 schematically presents how the camera system may determine the angle of incidence, and

Fig. 6 schematically shows a method of estimating glare perceived by a driver of a vehicle.

It should be noted that items denoted by the same reference numerals in different Figures have the same structural features and the same functions, or are the same signals. Where the function and/or structure of such an item have been explained, there is no necessity for repeated explanation thereof in the detailed description.

The Figures are purely diagrammatic and not drawn to scale. Particularly for clarity, some dimensions are exaggerated strongly.

Detailed description

A first embodiment is shown in Fig. 1. Fig. 1 schematically shows a portion of a car 102 with a light monitoring system. The car 102 is the device / apparatus / system which is provided with the light monitoring system according to the invention. The windshield of the car is a transparent window through which the driver receives light from light source(s) that might cause glare. The user of the light monitoring system is the driver of the car.

Fig. 1 presents a cross-sectional view of the car 102 and the cross-sectional view is made in the length of the car. At position 199 the x-z-dimension references are drawn. The x-dimension follows the surface on which the car is positioned or on which the car drives (assuming it is a flat surface). The increasing x-coordinates represent the (forward) driving direction of the car. The z-dimension is perpendicular to the surface on which the car drives, assuming it is a flat surface.

The car 102 has a windshield 116 through which a driver 106, who sits in the driver's seat 108 and looks into the forward driving direction of the car 102, observes the traffic and the environment. The sun and/or light sources of oncoming vehicles may emit too bright intensities of light (compared to the average lighting conditions at that particular moment) and this may be perceived by the driver 106 as glare. The first aspect of the invention provides a light monitoring system which is capable of monitoring whether the driver 106 perceives glare.

The light monitoring system comprises a camera system 114 which records the incident light, an user's eyes tracker 110 for determining a position of the driver's eyes 104, and a perceived glare estimator 122 for estimating whether the driver 106 perceives glare. The perceived glare estimator 122 comprises an incident light calculator 124.

The camera system 114 records received light intensities within a recording angle α_{xz}. It is to be noted that in Fig. 1 only the recording angle α_{xz} in the x-z-plane could be drawn. In Fig. 2b, the recording angle α_{xy} in the x-y plane has been drawn. The camera system 114 receives light intensities at different angles of incidence. In Fig. 2 and 3 examples of angels of incidence are discussed. The camera system 114 may comprise a camera 118. The camera 118 is, preferably, in the y-dimension (see Fig. 2b) a wide-angle camera which records in the y-dimension at least in a recording angle of 120 degrees. In use, the camera is directed into the driving direction of the car. Additionally, when the camera has a relatively wide recording angle, light which is received from the side and back of the car is also recorded by the camera system 114, to estimate, for example, whether the driver 116 perceives glare as the result of reflections of light from vehicles behind the car 102 in the mirrors of the car 102. In an embodiment, the camera 118 records images of the incident light every (relatively) short interval of time, or the camera 118 records a video stream of the incident light. The camera system 114 is coupled to the perceived glare estimator 122 and provides a recorded light intensity signal 120 to the perceived glare estimator 122 and the incident light calculator 124. The camera system 114 is located at a camera location. In an embodiment, the camera location is near the windshield 116 of the car 102. The camera system 114 may be positioned inside or outside the interior of the car 102 and the camera system 114 may be arranged below, above, left of or right of the windshield 116. The position of the camera system 114 is, in use, at least chosen such that the view of the driver 106 towards the road and the oncoming traffic is not obstructed.

The camera system 114 further estimates a distance between the camera system and the light source of the recorded incident light originates. It might be that light from more than one light source is received and the camera system 114 is at least capable of estimating a distance towards the light source of which the most intense light is received and may be capable of estimating distances towards a plurality of light sources. The information about the distance between the camera system 114 and the light source is provided in the recorded light intensity signal 120 to the perceived glare estimator 122 and the incident light calculator 124.

The user’s eyes tracker 110 determines the position of the driver’s eyes 104 and may optionally also determine a viewing direction of the eyes 104 of the driver. The user’s eyes tracker 110 may be arranged inside the car 102 at a position where the user’s eyes tracker 110 is capable of tracking the position of the eyes 104 of the driver 106. In an embodiment, the user’s eyes tracker 110 determines the position of both eyes 104 of the driver 106, or, in another embodiment, the user’s eyes tracker 110 determines the average of the position of both eyes 104 of the driver 106. The user’s eyes tracker 110 is coupled to the perceived glare estimator 122 and provides an eye position signal 112 to the perceived glare estimator 122. The user’s eyes tracker 110 may comprise all the hardware and/or software to determine the position of the eyes 104 of the driver 106, however, in an alternative embodiment, specific functions of the user’s eyes tracker 110 are distributed along different pieces of hardware. One of these pieces may a processing hardware (optionally running image processing software) which finally determines the position of the eyes 104 of the driver 106. Such processing hardware may be combined with other processing hardware of the light monitoring system, such as, for example of the perceived glare estimator 122 and/or the incident light calculator 124.

The user's eyes tracker 110 may comprise a camera which, in use, continuously images the driver's seat 108 and, thus, images the head and eyes 104 of the driver 106. The user's eyes tracker 110 may comprise image and video processing hardware and/or image and video processing software to recognize the position of the eyes 104 of the driver 106 in the images and/or video recorded from the driver's seat 108 for generating the eye position signal 112. The image and video recognition hardware and/or software may also be used to determine in which direction the driver 106 is looking. This may be determined on basis of the position of the head and on basis of the position of the pupils of the eyes 104 within the imaged eyes 104. In an alternative embodiment, the user's eyes tracker 110 comprises glasses which must be worn by the driver 106 and the glasses determine the position of the eyes 104 relatively to the position of the car and the direction in which the driver 106 is looking. It is to be noted that the invention is not limited to the discussed embodiments of the drier's eyes tracker 110.

The perceived glare estimator 122 and the incident light calculator 124 receive from the camera system 114 the recorded light intensity signal 120 and the eye position signal 112. The recorded light intensity signal 120 at least comprises information of light intensities that are received at specific angles of incidence within the recording angle α_{xz}, α_{xy}. The recorded light intensity signal 120 may comprise image information that is recorded by the camera 118 of the camera system 114, or may comprise a dedicated data stream which describes directly which light intensities are received from which directions. The perceived glare estimator 122 and the incident light calculator 124 may know the exact camera location of the camera system 114, or the camera system 114 also provides information about the camera location. Furthermore, the perceived glare estimator 122 and the incident light calculator may have knowledge about the recording angle α_{xz}, α_{xy} of the camera system 114. The recording angle may be stored in the perceived glare estimator 122 and/or the incident light estimator 124 or may be provided by the camera system 114 (for example, when the camera system uses a camera with an adaptable recording angle). The eye position signal 112 at least provides information about the position of the eyes 104 of the driver 106 and may optionally provide information about the direction in which the driver 106 is looking. A further predefined variable in the perceived glare estimator 122 and/or in the incident light estimator 124 is the angle within which the average human eye receives light, thus, the viewing angle of the average human eye.

The incident light calculator 124 122 is configured to transform the recorded incident light into perceived incident light at the position of the driver's eyes. Because of the difference between the driver's eyes position and the camera location, the driver's eyes receive other light intensities from different angles of incidence than it is received by the camera system 114. On basis of the available information, the incident light calculator 124 is capable of performing such a transformation.

In an embodiment, the transformation performed by the incident light calculator 124 calculates the perceived incident light on basis of angles of incidence of recorded light intensities, the camera location, the position of the driver's eyes and the estimated distance between the camera system and the light source.

Optionally, the incident light calculator 124 and/or the perceived glare estimator 122 are configured to apply a specific correction while transforming the recorded incident light into perceived light at the driver's eyes. Such a specific correction that may be applied in this transformation is a difference between the recording angle of the camera system 114 and the angle in which the human eye receives / sees light. Even in a more advanced embodiment, the incident light calculator 124 and/or the perceived glare estimator 122 is capable of correcting for different sensitivities of the average human eye for light intensities received from different directions - for example, the light which arrives at the human eye in exactly the same direction as the eyes are looking is experienced by the human eye as more intense light compared with the situation in which the same light source is located at the border of the view of the human eye. The incident light calculator 124 and/or the perceived glare estimator 122 is also capable to correct the perceived incident light at the position of the driver's eyes 104 for the viewing direction of the driver 106 - when the driver 106 looks more to the left, light intensities received from a direction at the right side of the car 102 are most probably not within the view of the driver's eyes 104. Different examples of the above discussed transformation are discussed in the subsequently discussed Figures. The incident light calculator 124 and/or the perceived glare estimator 122 is configured to use the transformed incident light at the position of the driver's eyes to reliably estimate whether the driver 106 perceives glare.

The perceived glare estimator 122 comprises the incident light calculator 124 and receives from the incident light calculator 124 the result of the transformation of the recorded incident light into the perceived incident light. The perceived glare estimator 122 is configured to estimate whether the driver perceives glare.

Fig. 1b schematically shows a pair of spectacles 150 which is provided with the light monitoring system according to the invention. The pair of spectacles comprises the transparent lenses 152 through which, in use, the human eyes receive light which may cause glare. The light monitoring system provided to the pair of spectacles is miniaturized and comprises two subsystems 154, 158. The first subsystem 154 at least comprises the camera system has a miniaturized camera which faces in the forward direction 156, which means, which faces into the direction the user of the pair of spectacles 150 is looking in normal use. The second subsystem 158 at least comprises the user's eyes tracker. The user's eyes tracker may have camera which faces into the direction 160 which is towards the eyes of the user. The second subsystem 158 only determines the position of one of the eyes of the user and the second subsystem 158 may estimate on basis of the determination at which position the other eye of the user is located. In another embodiment, the user's eyes tracker may be subdivided over the second subsystem 158 and a third subsystem (not shown) which is provided close to the other lens 152 of the pair of spectacles 150 such that the position of both eyes of the user can be accurately determined. The first subsystem 154 and the second subsystem 158 communicate with each other, either via a wired or a wireless connection. One of the first subsystem 154 and the second subsystem 158 comprise the incident light calculator.

In the subsequently discussed figures, the term driver is often used instead of the term user because examples are given in the context of a vehicle / car. Where appropriate, instead of "driver", the term "user" may be read.

Fig. 2a schematically shows the portion of the car 102 with light beams received from the sun 206. In Fig. 2 the camera location is indicated with the point P_c and the position of the eyes is indicated with P_e. The sun 206 is located at a distance away from the camera location P_c (seen in the x-dimension only). The light ray 202 represents the 2 dimensional vector from the sun towards the camera location P_c. In particular for the sun the distance between the sun and the camera location P_c may be approximated with *infinity* (∞). The perceived glare estimator may estimate the distance between the camera system and the source of the light beam. For example, objects are recognized, or movements of the object are recognized, and distances to objects are estimated. In another embodiment, the camera system comprises a 3D camera which obtains images from two slightly different camera locations such that a distance to an imaged light source may be estimated. In another embodiment, the camera system 114 comprises distance measurement means which transmit radio or light signals to the objects and measure the time required for reflections of these wave to return to the camera system 114 such that the distance to the objects may be calculated.

A first light ray 202 of the sun 206 arrives at the camera location P_c at the angle of incidence β_c. The angle of incidence is defined as the angle between the received light ray 202 and a reference plane. In the schematic cross-sectional view of Fig. 2, the reference plane is the plane defined by z=0. In real, 3d situations, the angle of incidence must also be defined with respect to a second plane, which is, for example, the plane defined by y=0. This will be shown in the context of Fig. 2b. The first light ray 202 arrives with an intensity I_c at the camera location P_c. The light ray 202 of the sun 206, which arrives at the camera location P_c, is different from a second light ray 204 which arrives at the position P_e of the eyes of the user. The second light ray 204 arrives with the angle of incidence β_e at the position P_e of the eyes of the driver 106 and arrives with the intensity I_e at the position P_e of the eyes of the driver 106. The perceived incident light calculator estimates, on basis of available information, at which intensity of light I_e the second light ray arrives at the eyes of the driver 106. This is done by transforming the information received at the camera location P_c into information received at the position P_e of the eyes of the driver.

For example, in the example of Fig. 2 the incident light calculator determine that they light source is the sun 206 and that, because the distance to the sun is about *infinity* (∞), the intensity received at the different positions P_c, P_e is almost equal because light rays of a light source that is located at an infinite distance arrive substantially parallel. It also means that the incident light calculator may determine that the intensities received at the different positions P_c, P_e is almost equal to each other. It might be that the driver 106 is looking into another viewing direction. In that situation the perceived glare estimator estimates whether the driver 106 will still receive, within his viewing angle, the intense sunlight to estimate whether the driver 106 perceives glare.

In an embodiment, the perceived glare estimator compares the different light intensities as perceived by the eyes of the driver 106 with a glare threshold value to determine whether the user perceives glare. If the value of one or more different light intensities (received from possible different angles of incidence) as perceived by the eyes of the driver 106 is larger than the threshold value, a glare signal is generated which indicates that the driver 106 perceives glare. In a specific embodiment, the perceived glare estimator also determines the angles of incidence β_e at the eyes of the driver 106 at which too high intensities of light are perceived by the eyes of the driver 106 and these angles of incidence β_e are communicated to other systems of the car via the glare signal. The glare threshold value may a fixed predetermined value, but an advantageous embodiment, the glare threshold value is automatically adapted to the average lighting conditions. Optionally, the light monitoring system may comprise an average lighting condition sensor which measures the overall average lighting conditions, wherein average must be seen as the average amount of light received from a plurality of directions and some averaging in time may be performed as well (however, the eyes of the driver 106 adapt to other lighting conditions within a relatively short time , for example, when the car enters a tunnel and the averaging in time should not be much longer than the adaptation time of the human eye).

In Fig. 2a a third position is indicated with the reference sign P_i. The third position P_i is the location where the light ray or light beam (with a relatively high or too high intensity of light) intercepts with a windshield of the car. The light monitoring system (for example, the perceive glare estimator of the light monitoring system), or other systems in the car may be configured to calculate this point such that it is known around which position the light transmittance of the windshield is preferably reduced to reduce the perception of glare by the driver 106.

Fig. 2b presents a similar embodiment as the embodiment of Fig. 2a. Fig. 2b schematically presents a cross section view of the car 102 along a plane parallel to the x-y plane seen from a position above the car 102. The head 302 of the driver is seen. In such a view from above, two eyes 104 of the driver are seen. For simplicity the average of the two eyes 104 position is taken in Fig. 2b as the position P_e of the eyes 104 of the driver. In embodiments of the light monitoring system, the incident light calculator may calculate the perceived incident light for each individual eye 104 and, thus, the perceived glare estimator may estimate the perceived glare for each individual eye 104.

Fig. 2b schematically shows a top view of the portion of the car 102 with a light source 304. In the embodiment of Fig. 2b, the camera location P_c is at the left side of the driver near the windshield. At the right end of the figure, a light source 304 is drawn which is, for example, of an oncoming vehicle (e.g. motorcycle). Especially, during the night, when the average lighting conditions are relatively dark, the light source 304 may emit such an amount of light that the driver perceives glare. As shown in Fig. 2b, the light ray which arrives at the camera location P_c arrives at a larger angle of incidence γ_c than the angle of incidence γ_e of the light ray which arrives at the position P_e of the eyes of the driver. It is to be noted that the above discussion is based on two dimensional images. In practice the perceived glare estimator determines the angles, vectors and distances in the three dimensional space and uses well known geometrical and optical formulas which are adapted for the three dimensional space.

In Fig. 2b the recording angle α_{xy} of the camera system in the y-dimension is presented. The recording angle of the camera system is in at least one dimension larger than 120 degrees, such as, for example in the y-dimension. In another embodiment, the recording angle of the camera system in in at least one dimension larger than 150 degrees, or more than 170 degrees.

Fig. 3 schematically shows a 3d model 350 of the different locations and positions of the camera system, the eyes of the driver and the location of the light source. In the 3d model 350 the x, y and z-axis of the Cartesian coordinate system are indicated. The light source is indicated with S and the location of the light source is schematically indicated by the coordinate (x_s, y_s, z_s). The camera location is indicated with point P_c and it is assumed that the origin of the coordinate system and, thus, coordinate (0, 0, 0). The position of the eyes of the driver is indicated with the point P_e and has the coordinate (x_e, y_e, z_e). Intensity I_e and intensity I_c are the light intensities transmitted towards, respectively, the eyes of the driver and the camera system. At the camera location P_c the light ray from the light source S arrives at angles of incidence β_c, γ_c. The angle of incidence β_c is the angle between the xy-plane and the light ray received from the light source S and the angle of incidence γ_c is the angle between the x-axis and a projection of the light ray received from the light source S at the camera location P_c on the xy-plane. Point S_0 is a projection of the light source to the yz-plane of the coordinate system.

In the following, a formula is deducted to calculate the intensity of the light of the light source that is received at the position of the eyes of the driver P_e=(x_e, y_e, z_e) when the camera location P_c and the position of the eye of the driver P_e are known, the angles of incidence β_c, γ_c at the camera system of the light of the light source S are known and when the distance from the camera location P_c towards the light source S is estimated. A distance between two point is indicated with the reference signs of the two points. For example SP_c is a variable that represents the distance between the light source S and the camera location P_c. The deduction follows the subsequent formulas:

The coordinates of the light source S = (x_s, y_s, z_s) may be determined with:

$$x_s = SP_c \cdot \cos\beta_c \cos\gamma_c$$

$$y_s = SP_c \cdot \cos\beta_c \sin\gamma_c$$

$$z_s = SP_c \cdot \sin\beta_c$$

A distance between the light source S and the projection of the light source S_0 is x_s.

A distance between the projection of the light source S_0 and the location of the camera P_c is:

$$S_0P_c = \sqrt{{y_s}^2 + {z_s}^2}$$

A distance between the light source S and the location of the camera P_c is:

$$SP_c = \sqrt{{x_s}^2 + {y_s}^2 + {z_s}^2}$$

Subsequently, the cosine of the indicated angle θ_c can be calculated:

$$\cos\theta_c = \frac{SS_0{}^2 + SP_c{}^2 - S_0P_c{}^2}{2SS_0 \cdot SP_c} \quad (1)$$

The same deductions may be performed for distances between the (projected) light source S, S_0 and the position of the eyes of the user:

$$S_0P_e = \sqrt{x_e{}^2 + (y_e - y_s)^2 + (z_e - z_s)^2}$$

$$SP_e = \sqrt{(x_e - x_s)^2 + (y_e - y_s)^2 + (z_e - z_s)^2}$$

Which results a cosine of the indicated angle θ_e:

$$\cos\theta_e = \frac{SS_0{}^2 + SP_e{}^2 - S_0P_e{}^2}{2SS_0 \cdot SP_e} \quad (2)$$

According to Lambert's cosine law: $I_0 = I_e/\cos\theta_e = I_c/\cos\theta_c$

And, thus,

$$I_e = I_c \cdot \frac{\cos\theta_e}{\cos\theta_c} \quad (3)$$

By calculating (1) and (2) and filling in these values in (3), the perceived light intensity at the driver's eyes can be calculated on basis of known information.

When formulas (1) and (2) are filled in (3) and the formula is simplified, the relation between the intensity I_e of the light received at the eyes of the driver is formed by:

$$I_e = I_c \cdot (1 - \frac{x_e}{x_s}) \frac{SP_c}{SP_e} \quad (4)$$

Fig. 4 schematically shows a glare prevention system 400 comprising a light monitoring system 402. The light monitoring system 402 comprises a camera system 404 for recording incident light, a driver's eyes tracker 406 for determining a position of the driver's eye and for optionally determining a viewing direction of the eyes of the driver, an incident light calculator 409 for calculating perceived incident light by the driver's eyes and a perceived glare estimator 408 for estimating whether the driver perceives glare. Embodiments of the light monitoring system 402 have been discussed in the context of previous Figures. The perceived glare estimator 408 generates a glare signal 410. The glare signal 410 indicates whether the user (most probably) perceives glare. In a specific embodiment, the glare signal 410 also indicates from which angle of incidence (at the driver's eyes) the light is received which cause the perceived glare. In other optional embodiments, the light monitoring system 402 also provides information of the position of the driver's eyes to other components of the glare prevention system 400. The glare prevention system 400 further comprises a dynamic light intensity filter 416 which is, in use, arranged in between a front side of the vehicle (which comprises the glare prevention system 400) and the driver's seat. The dynamic light intensity filter 416 is configured to reduce a light intensity transmitted through the dynamic light intensity filter 416 in response to a dimming signal 414. The glare prevention system 400 is configured to reduce the glare perceived by the driver of the vehicle by reducing the light intensity transmitted through the dynamic light intensity filter 416 when the light monitoring system 402 determines that the driver experiences glare. In an embodiment, the glare prevention system 400 comprises a prevention controller 412 which performs the above discussed task. The prevention controller 412 receives the glare signal 410 and generates the dimming signal 414 such that, when the light monitoring system 402 determines that the driver experiences glare (as indicated by the glare signal 410), the dynamic light intensity filter 416 reduces the light intensity transmitted through the dynamic filter 416.

In an embodiment, the dynamic light intensity filter comprises a plurality of pixels which can be individually controlled to reduce the light intensity transmitted through the pixels. In an embodiment of the glare prevention system 400 (for example, in an embodiment of the prevention controller 412 by perceived glare estimator) the glare prevention system 400 is configured to estimate at which intersection location of the dynamic light intensity filter 416 the light beams or light rays that are perceived as glare intersect with the dynamic light intensity filter 416 and the dimming signal 414 indicates that the pixels at, and optionally around, the intersection location have to reduce their light transmittance. In order to determine the intersection position, the glare prevention system 400 has to know how the dynamic light intensity filter is arranged relatively to the driver's eye position. In an embodiment, the dynamic light intensity filter is arranged on the glass of the windshield and the glare prevention system 400 knows exactly the position, orientation and shape of the windshield.

When the glare prevention system 400 of Fig. 4 is used in combination with a pair of spectacles / glasses, the dynamic light intensity filter 416 may be provided on the lenses of the pair of spectacles / glasses.

Fig. 5 schematically presents how the camera system may determine the angle of incidence β_c. Fig. 5 shows some elements of a camera of the camera system. The camera comprises an image sensor 508 which comprises pixels that record a light intensity that impinges on the respective pixels. The camera further comprises an optical system that is presented in a simplified manner by means of lens 506. A central optical axis 504 is also drawn. The distance d from the lens 506 to the image sensor 508 is known. If a specific pixel records a specific light intensity, the distance k from the pixel towards the central optical axis 504 is known as well. Subsequently, the camera system is able to calculated the angle

$\alpha = \tan^{-1}(k/d)$. Based on knowledge of the optical system (such as focal distance, etc.), the camera system is capable of determining the angle of incidence β_c. In another embodiment, especially when the refraction behavior of the optical system of the camera is not uniform along the whole recording angle, an empirical model is obtained which describes how angles of incidence β_c relate to the angles α (defined between the light ray, which impinges on the image sensor 508, and the central optical axis 504). Thus, the camera system of the light monitoring system may determine the angle of incidence, based on the above information, or camera of the camera system provides an image and a position of pixels in the image relate to positions of pixels on the image sensor and the camera system may determine on basis of the above discussed principles and the position of the pixel in the image what the angle of incidence of the receive light ray was, or the perceived glare estimator determines the angle of incidence at the camera location on basis of the position of the pixels in the image and the above discussed principles.

Fig. 6 schematically shows a method 600 of estimating glare perceived by a driver of a vehicle. The method comprises the stages of: i) recording 602 from a camera location light intensities received at different angles of incidence with a recording angle, ii) determining 604 a position of the driver's eyes and/or determining a viewing direction of the eyes of the driver, iii) transforming 606 the recorded incident light into perceived incident light at the position of the driver's eyes, wherein, while transforming, a correction is applied to correct at least for one of the following: a difference between the camera location and the positions of the driver's eyes, a difference in the recording angle and an angle in which human eyes receive light, and the viewing direction of the driver, iv) estimating 608 whether the driver perceives glare. It is to be noted that the above stages of the method 600 are, in use, repeated continuously. Some of the stages may also be performed in parallel to each other, such as, for example, the stages of recording 602 light intensities and determining 604 a position of the driver's eyes.

Optionally, a computer program is provided which comprises instructions for causing a processor system to perform a subset of the stages the method 600. Optionally, the computer program may be embodied on a computer readable medium

In summary, a light monitoring system, a glare prevention system, a method of monitoring glare and a vehicle are provided by the invention. The light monitoring system comprises a camera system, a user's eye tracker and an incident light calculator. The camera system records incident light from a light source and is configured to record light intensities received at angles of incidence. The camera system also estimates a distance to the light source. The user’s eye tracker determines a position of the user’s eyes. The incident light calculator calculates perceived incident light by the user’s eyes and transforms the recorded incident light into the perceived incident light. The perceived incident light may be used to estimate whether the user perceives glare and this information may be used to control a dynamic light intensity filter such that the light originating from a too bright light source is dimmed.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims.

In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. Use of the verb "comprise" and its conjugations does not exclude the presence of elements or steps other than those stated in a claim. The article "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. The invention may be implemented by means of hardware comprising several distinct elements, and by means of a suitably programmed computer. In the device claim enumerating several means, several of these means may be embodied by one and the same item of hardware. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

CLAIMS:

1. A light monitoring system (402) comprising

- a camera system (114, 404) for recording incident light (202) from a light source, the camera system (114, 404) being configured to record, from a camera location (Pc), light intensities from the light source,

- a user's eyes tracker (110, 406) for determining a position (Pe) of the user's eyes (104),

- an incident light calculator (124) for calculating perceived incident light by the user's eyes (104), wherein the incident light calculator (124) is configured to transform the recorded incident light intensities at the camera location (Pc) into the perceived incident light intensities at the position (Pe) of the user's eyes.

2. A light monitoring system (402) according to claim 1, wherein

- the camera system (114, 404) is configured to determine for the recorded light intensities their angles of incidence (β_c, γ_c) and to estimate a distance to the light source,

- the incident light calculator (124) is configured to calculate the perceived incident light intensities on basis of angles of incidence (β_c, γ_c) of recorded light intensities, the camera location (Pc), the position of the user's eyes (104) and the estimated distance between the camera system (114, 404) and the light source.

3. A light monitoring system (402) according to claim 1 further comprising a perceived glare estimator (122, 408) for estimating whether the user (106) perceives glare, the perceived glare estimator (122, 408) comprises the incident light calculator.

4. A light monitoring system (402) according to claim 1, wherein the camera system records incident light (202) from the light source within a recording angle (α_{xz}, α_{xy}) and, in use, the recording angle (α_{xz}, α_{xy}) is directed, in use, into a direction (x) in which the user, in normal use, looks.

5. A light monitoring system (402) according to claim 4, wherein the camera system (114, 404) comprises a wide-angle camera wherein the recording angle (α_{xz}, α_{xy}) is wider than 120 degrees.

6. A light monitoring system (402) according to claim 1, wherein the camera location (Pc) is near the transparent window.

7. A light monitoring system (402) according to claim 1, wherein the item is a vehicle (102) and the transparent window is a windshield (116) of the vehicle (102).

8. A light monitoring system (402) according to claim 7, wherein the user's eyes tracker (110, 406) comprises a video recognition system which receives images from the further camera and which is configured to detect in the received images the positions (Pe) of the user's eyes (104).

9. A light monitoring system (402) according to claim 3, wherein the perceived glare estimator (122, 408) is configured to determine whether the perceived incident light intensities exceed a glare threshold value and wherein the perceived glare estimator is configured to generate a glare signal (410) when it has been determined that the perceived incident light intensities exceed the glare threshold value.

10. A light monitoring system (402) according to claim 9, wherein the perceived glare estimator (122, 408) is also configured to determine whether perceived incident light intensities received at an estimated angle of incidence (β_e, γ_e) at the positions (Pe) of the user's eyes (104) exceed the glare threshold value and wherein the glare signal (410) also indicates the estimated angle of incidence (β_e, γ_e).

11. A glare prevention system (400) for use with or in an item comprising a transparent window through which light is transmitted towards eyes of a user, the glare prevention system (400) comprising

- a light monitoring system (402) according to any one of the claim 1 to 10,
- a dynamic light intensity filter (416) for arrangement in between the light source which might cause glare and the position (Pe) of the eyes of the user, the dynamic

light intensity filter being configured to reduce a light intensity transmitted through the dynamic light intensity filter in response to a dimming signal (414), wherein the glare prevention system (400) is configured to reduce the glare perceived by the user by at least partially reducing the light intensity transmitted through the dynamic light intensity filter (416) when the light monitoring system determines that the user (106) experiences glare.

12. A glare prevention system (400) according to claim 11, when directly or indirectly referring back to claim 3, wherein

- the dynamic light intensity filter (416) is configured to locally reduce a light intensity transmitted through a portion the dynamic light intensity filter (416) in response to the dimming signal (414) which indicates which portion of the dynamic filter must reduce the light intensity transmitted through the portion,
- the perceived glare estimator (122, 408) is configured to estimate through which portion of the dynamic light intensity filter (416) the light that is perceived as glare by the user (106) is transmitted, and to generate the dimming signal (414) indicating the portion, wherein, in the generation of the dimming signal (414) indicating the portion, a position of the dynamic light intensity filter with respect to the positions (Pe) of the user's eyes (104) and the camera location (Pc) is taken into account.

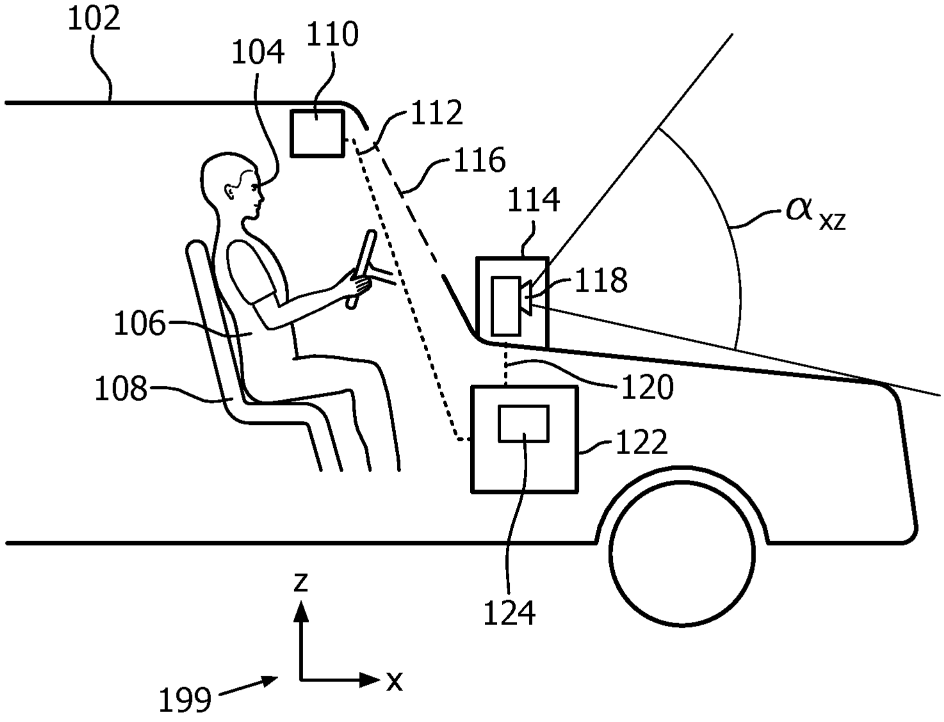
13. A vehicle (102) comprising the light monitoring system (402) according to claim 1, or the glare prevention system (400) according to claim 11.

14. A method (600) of monitoring glare, the method comprises the stages of

- recording (602) from a camera location light intensities received from a light source,
- determining (604) a position of the user's eyes,
- transforming (606) the recorded incident light intensities into perceived incident light intensities at the position of the user's eyes.

15. A method (600) according to claim 14 further comprising the stage of:

- estimating on basis of the perceived incident light intensities at the position of the user's eyes whether the user perceives glare.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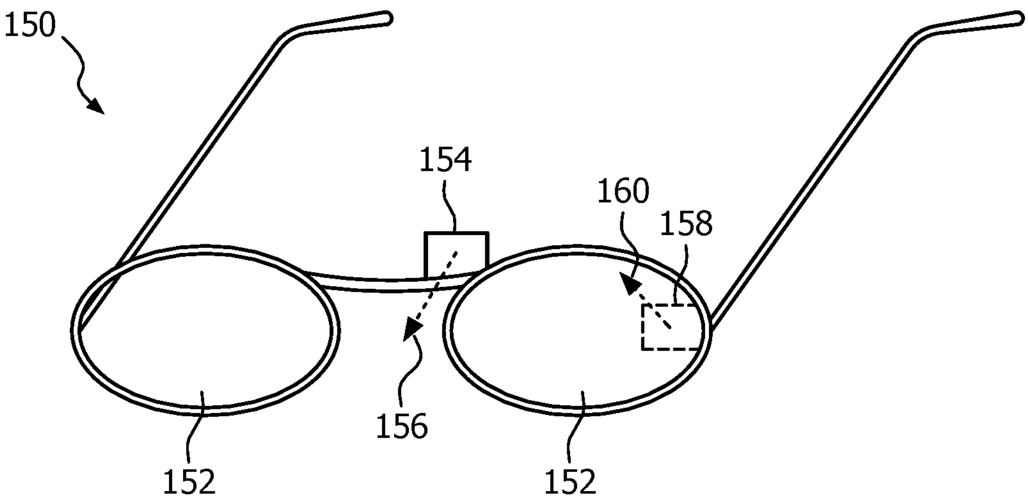
110
112
116
114
118
α_{xz}
106
108
120
122
124
z
x
199

FIG. 1a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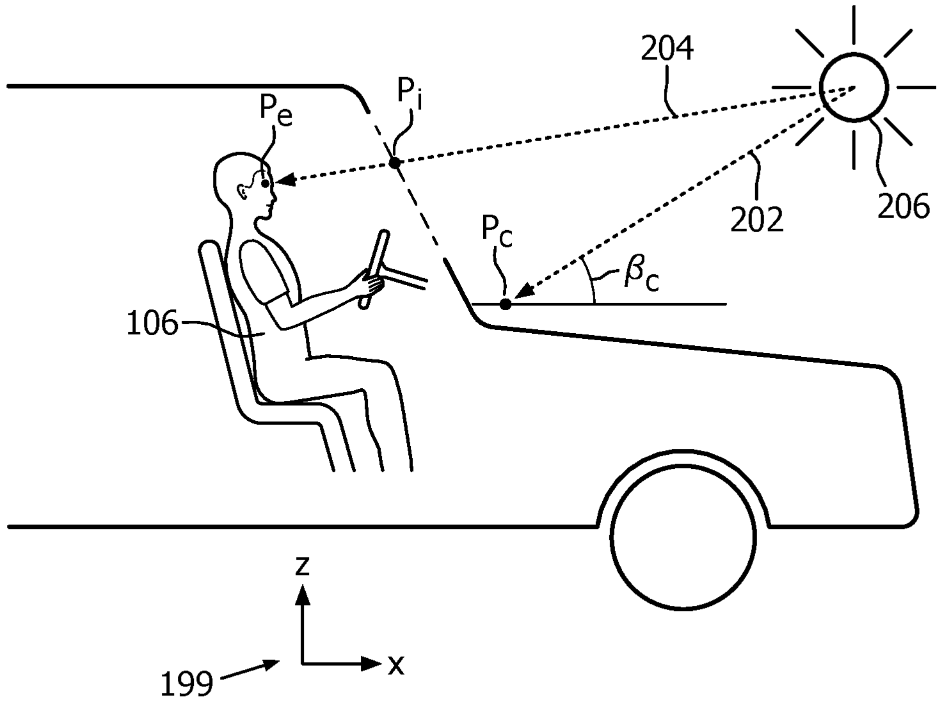
154
160
158
156
152
152

FIG. 1b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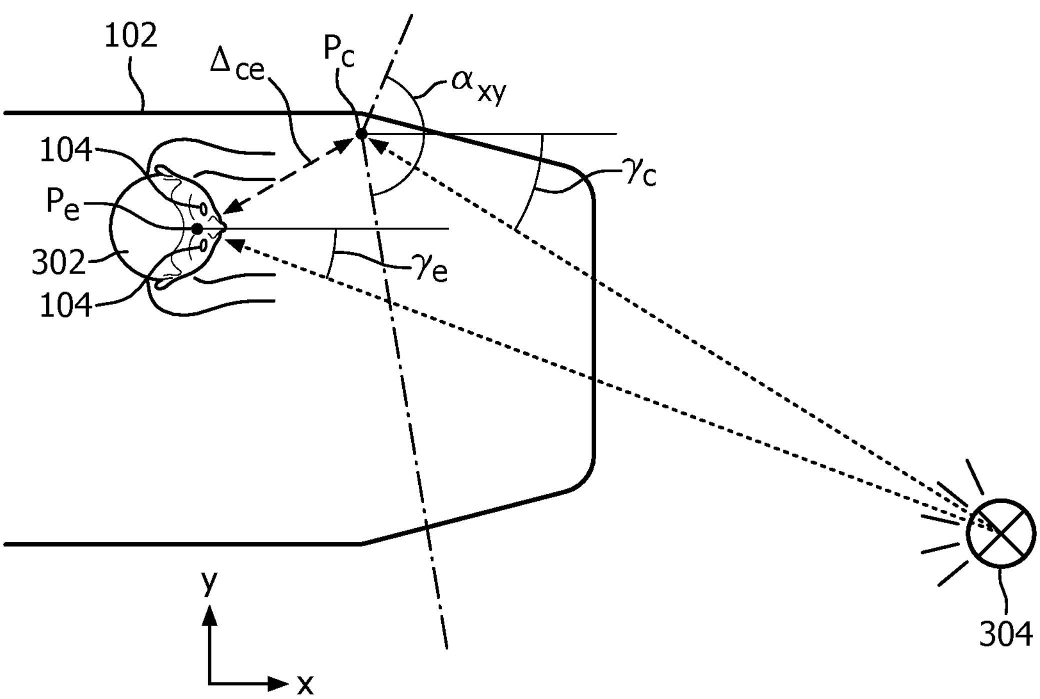
P_i
P_e
206
202
P_c
β_c
106
z
x
199

FIG. 2a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P_c
α_{xy}
104
γ_c
P_e
302
γ_e
104
y
x
304

FIG. 2b

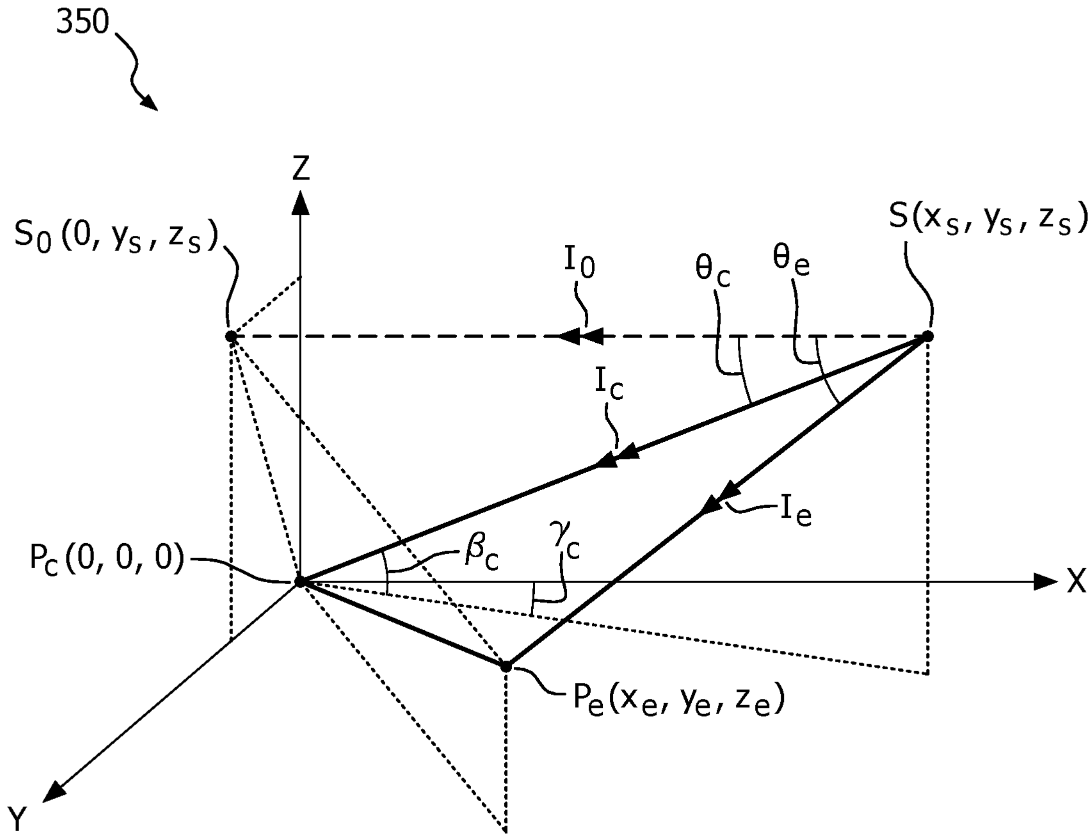

FIG. 3

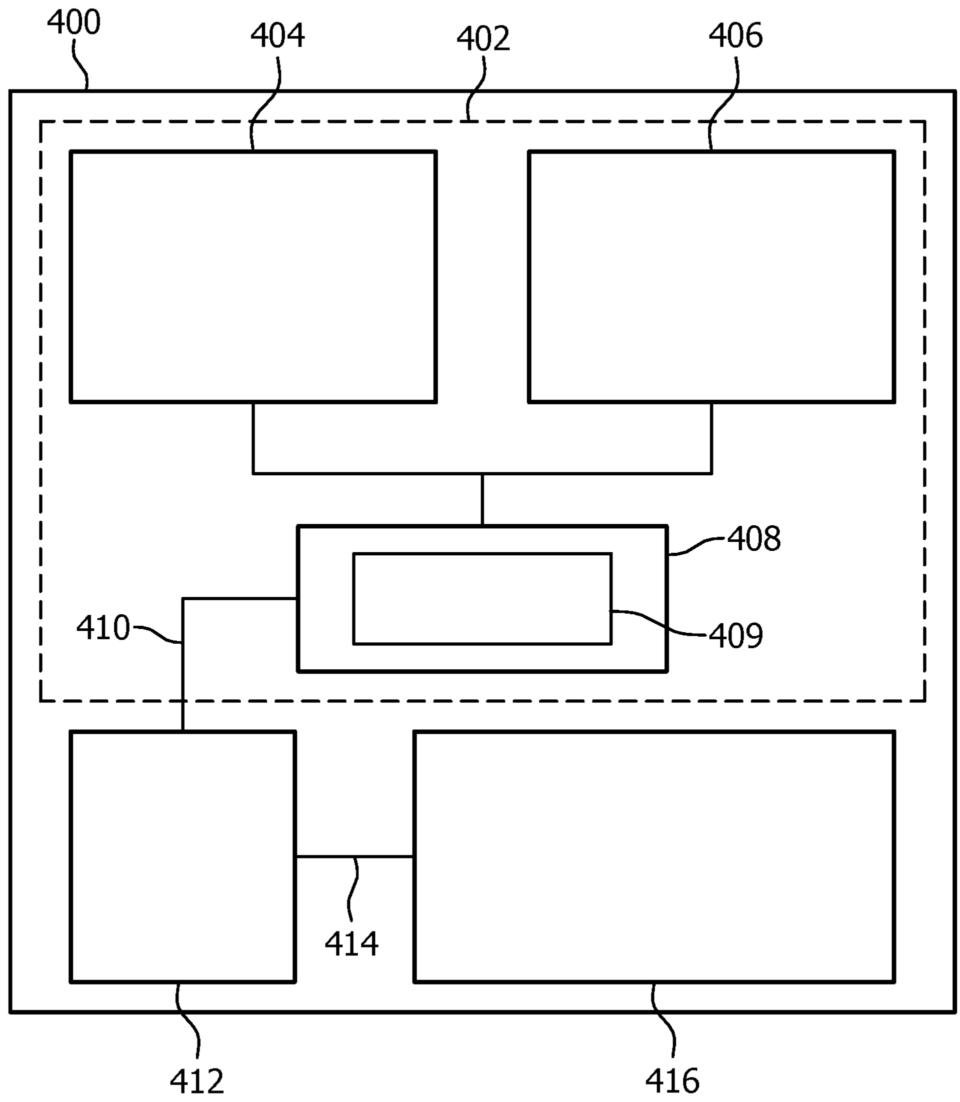

FIG. 4

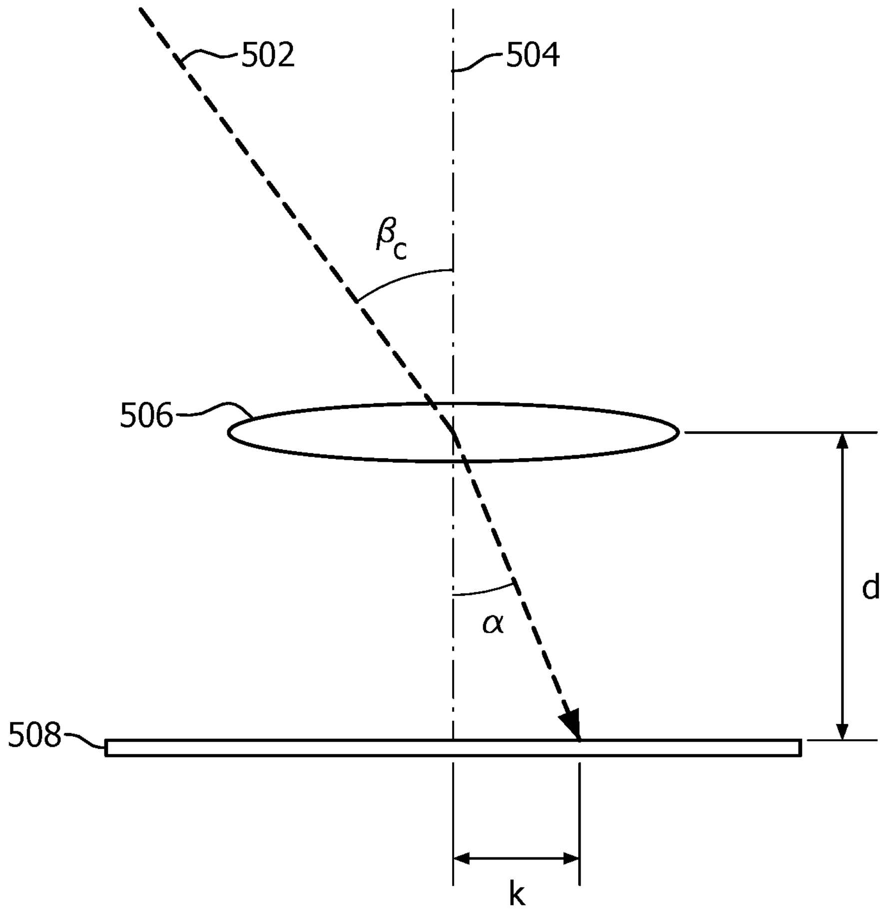

FIG. 5

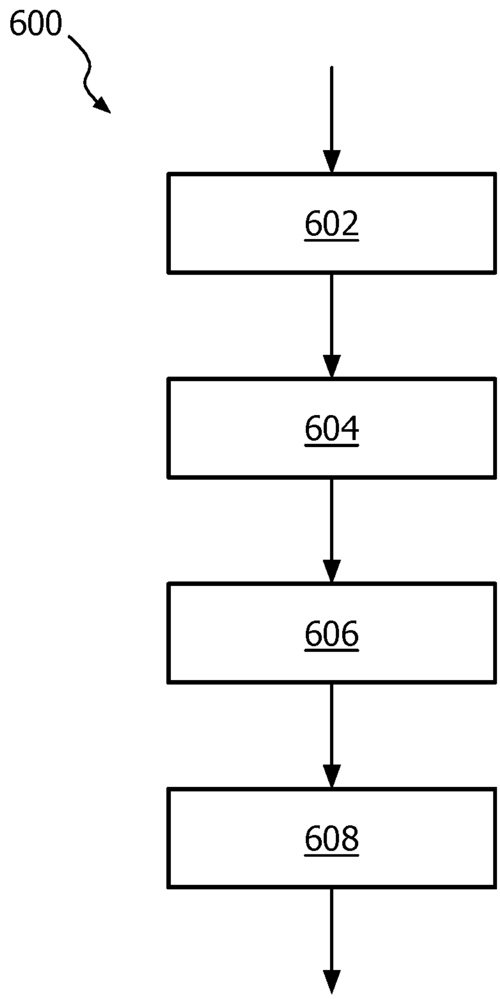

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2014/061650

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01J1/02 G01J1/26 B60J3/04
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01J B60J

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2006 024004 A1 (SIEMENS AG [DE]) 29 November 2007 (2007-11-29) paragraph [0017] - paragraph [0031] figures 1-3	1,3-15
X	US 2006/140502 A1 (TSENG ALLAN S [US] ET AL) 29 June 2006 (2006-06-29) paragraph [0011] - paragraph [0022] figures 2, 3	1-15
X	US 5 305 012 A (FARIS SADEG M [US]) 19 April 1994 (1994-04-19) column 5, line 15 - column 12, line 12 figures 1-11	1-15

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 August 2014	29/08/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Haller, Mirjam

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 683 668 A2 (HITACHI LTD [JP]) 26 July 2006 (2006-07-26) paragraph [0013] - paragraph [0042] figures 1-4, 11-13	1-15
X	GB 2 445 365 A (GARRARD MICHAEL ROBERT [GB]) 9 July 2008 (2008-07-09) page 3, paragraph 4 - page 6, paragraph 2 figures 1-4	1,3-15

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2014/061650

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102006024004 A1	29-11-2007	NONE	
US 2006140502 A1	29-06-2006	NONE	
US 5305012 A	19-04-1994	US 5305012 A	19-04-1994
		WO 9321624 A1	28-10-1993
EP 1683668 A2	26-07-2006	EP 1683668 A2	26-07-2006
		JP 4533762 B2	01-09-2010
		JP 2006199104 A	03-08-2006
		US 2006158715 A1	20-07-2006
GB 2445365 A	09-07-2008	NONE	