The invention relates to a method of raindrop detection on a windscreen by capturing images on said windscreen, including a step of edge detection (102) in an area of interest of said captured images, characterized in that said method further comprises a step of scaling (101) the captured images pixels in function of the ambient light level passing through said windscreen before detecting edges. The invention also relates to an associated device for raindrop detection.

**FIG. 1**

100

101

102
Method and device of raindrop detection on a windscreen

The invention relates to a method and a device of raindrop detection on a vehicle windscreen by processing images, particularly in order to trigger the automatic control of a functionality of the vehicle, particularly that of the windscreen wipers.

In motor vehicles, several driving assistance systems are known, using images captured by a single or by several cameras.

The images obtained can be processed to allow a display on screens, for example at the dashboard or projected on the windscreen, in particular to alert the driver in the case of danger or simply to improve his visibility. The images can also make it possible to detect raindrop or fog on the windscreen.

These images can participate in the automatic triggering of a functionality of the vehicle (alert to the driver, automatic triggering of braking, automatic triggering of the windscreen wipers in the case of the display of drops of water on the windscreen, visual or audible warning, control of certain functions of the headlight, etc).

However, raindrop detection may not be always well adapted to the environmental lighting changes, such as during the night or during a tunnel crossing by the vehicle.

An object of the invention is therefore to overcome this drawback by proposing an improved method and an improved device for raindrop detection on a windscreen in changing lighting environment, such as by night or during a tunnel crossing.

In a first aspect of the present invention, this object is achieved by a method of raindrop detection on a windscreen by capturing images on said windscreen, including a step of edge detection in an area of interest of said captured images, characterized in that said method further comprises a step of scaling the captured images pixels in function of the ambient light level passing through said windscreen before detecting edges.

Then, the pixels of the captured images are scaled in function of the ambient windscreen light level, becoming independents of the changing lighting environment. Thus, as the pixels of the captured images are scaled in function of the ambient windscreen light...
level, the detection thresholds of the edge detection filter can remain fixed. It is no longer necessary to modify the two hysteresis thresholds of the edge detection filter when the environmental luminosity is changing. Moreover, the images contrast is enhanced allowing a better sharpness.

According to an embodiment, the scaling step converts the intensity of each pixel in function of a target mean and a target standard deviation of the pixels distribution of said area of interest.

Said target mean may be equal to the pixels range mean.

Said target standard deviation may be equal to the pixels range divided by six.

Indeed, as the pixels distribution in said area of the captured images is considered to be of the Normal or Gaussian type, the ideal distribution should have the target mean in the center of the pixel range. Moreover, experimentation has shown that a target standard deviation of 1/6 range is ideal.

With regard to another aspect, the scaling of the captured images is done while the captured images are converted into images comprising a depth adapted to be processed and displayed. Thus, the method of raindrop detection can benefit of the calculation already needed to the images conversion.

The invention also relates to a device for raindrop detection on a windscreen comprising:

- a camera for being mounted onboard a vehicle and configured to view the windscreen on said vehicle, and

- processing means configured to capture images from said camera and to detect edges in the captured images, and to generate at least one signal indicative of the presence of raindrop on said windscreen from information contained in the captured images,

characterized in that the processing means further comprise adaptive scale means configured to implement said method of raindrop detection.
Said adaptive scale means may further be configured to convert the captured images into images comprising a depth adapted to be processed and displayed.

According to an embodiment, said camera provides 12-bits images, said processing means are configured to process 8-bits images, said device for raindrop detection includes a display mean of 8-bits images and said adaptive scale means are configured to scale the captured images pixels in function of the ambient light level passing through the windscreen while converting the 12-bits captured images into a 8-bits processed and displayed images.

As an example, processing means are further configured to generate at least one signal indicative of the presence of raindrop on said windscreen from information contained in the captured images.

Other features and advantages of the invention will become apparent from the following description of a non-limited example and enclosed drawings.

The device for raindrop detection comprises a camera mounted onboard a motor vehicle, configured to view the windscreen on said vehicle. The camera is installed in the cab interior of the vehicle, opposite a "wipable" zone of the windscreen, that is to say a zone which is swept by one of the wiper blades while in operation. The camera takes successive images of the road in front of the vehicle through the windscreen. For example, the camera is mounted behind the windscreen wiped area, at approximately ten to twenty centimeters from it.

As used herein, the term "camera" is used to designate any device for acquiring images of the camera type (more particularly the CCD ("charge coupling sensor")s) or
CMOS (Complementary Metal Oxide Semiconductor) type) or photosensitive sensor, for example a black and white sensor or a color sensor.

The camera supplies signals representing images that can then be processed. The camera is generally sensitive in the visible range and/or in the infrared range, in particular in the near infrared.

The device for raindrop detection also comprises processing means configured to capture images from said camera and to generate at least one signal indicative of the presence of raindrop on said windscreen from information contained in the captured images.

The processing means further comprise adaptive scale means configured to implement a method of detecting the presence of raindrop on a windscreen 100 (figure 1).

Said method 100 includes a step of edge detection 102 in an area of interest of said captured images and a step of scaling 101 the captured images pixels in function of the ambient light level passing through said windscreen before detecting edges. The ambient light is the environmental luminosity of the vehicle passing through the windscreen. The area of interest is a region selected in the captured images.

In one embodiment, the scaling step 101 converts the intensity of each pixel in function of a Target Mean and a Target Standard deviation of the pixels distribution of the area of interest, so that the scaling is adaptive with the changing luminosity.

The conversion may be a proportional one.

For example, the converted intensity $I'$ is calculated with the linear relation (1):

\[ F(i) = \text{Scale} \times I(i) + \text{Shift} \]

with $I(i)$ the intensity $I$ of each pixel $i$.

The "Scale" coefficient is issue from the relation (2):

\[ \text{Scale} = \frac{\text{Target Standard deviation}}{\text{Standard deviation}} \]

For example, the Target Standard deviation is equal to the pixel range divided by six. The Standard deviation is calculated for the pixels distribution of the area of interest.

The "Shift" value is issue from the relation (3):

\[ \text{Shift} = \text{Target Mean} - \text{Scale} \times \text{Mean} \]

For example, the Target Mean is equal to the pixel range mean. The Mean is calculated for the pixels distribution of the area of interest.
The Figure 2 illustrates a grey level histogram of an 8-bits image. The histogram associates the number of pixels in the image with each grey level. The histogram is on the left side, in low values that are characteristic of dark images (as we can see it on degraded grey scale below the histogram). The pixel range is [0 — 255], then the target mean is 128 and the target standard deviation is 42.

The figure 3 illustrates the modified image obtained after scaling. The modified histogram mean is then in the middle of the pixel range, characteristic of a modified image neither too dark nor too bright.

Indeed, as the pixels distribution in said area of the captured images is considered to be of the Normal or Gaussian type, the ideal distribution should have the target mean in the center of the pixel range. Moreover, experimentation has shown that a target standard deviation of 1/6 range is ideal. Then, the captured images pixels are scaled in function of the ambient windscreen light level, being normalized in front of the changing lighting environment, such as when the vehicle crossing a runnel or when the night is coming.

Moreover, the images contrast is enhanced allowing a better sharpness.

According to a further embodiment, the adaptive scale means are configured to scale the captured images in function of the ambient light level passing through the windscreen while converting the depth captured images into a depth images adapted to be processed and displayed. The depth is the number of bits used to represent the grey level of a pixel.

Thus, the method of raindrop detection 100 can benefit of the calculation already needed to the images conversion.

As an example, the camera provides 12-bits images, processing means are configured to process 8-bits images and the device for raindrop detection includes a display mean of 8-bits. Thus, the adaptive scale means scale the captured images in function of the ambient light level passing through the windscreen while converting the 12-bits captured images into a 8-bits processed and displayed images.

Then, said method of raindrop detection 100 includes a step of detecting edges 102. In non-limiting examples, edge detection methods such as the Sobel, Prewitt, Roberts, Zero-cross, Canny methods etc. can be used.

The edge detection allows generating a set of curves corresponding to boundaries of objects seen in the field of view of the camera passing through the windscreen. Detected
objects are potentially drops on the windscreen, obstacles or lanes on the road. Raindrops can be separated from other objects using selection rules and characteristics of each set.

Thus, as the pixels of the captured images are scaled in function of the ambient windscreen light level, the detection thresholds of the edge detection filter can remain fixed. It is no longer necessary to modify the two hysteresis thresholds of the edge detection filter when the environmental luminosity changes.
7

CLAIMS

1. Method of raindrop detection on a windscreen by capturing images on said windscreen, including a step of edge detection (102) in an area of interest of said captured images, characterized in that said method further comprises a step of scaling (101) the captured images pixels in function of the ambient light level passing through said windscreen before detecting edges.

2. Method of raindrop detection according to claim 1, characterized in that the scaling step (101) converts the intensity of each pixel in function of a target mean and a target standard deviation of the pixels distribution of said area of interest.

3. Method of raindrop detection according to claim 2, characterized in that said target mean is equal to the pixel range mean.

4. Method of raindrop detection according to one of claim 2 or 3, characterized in that said target standard deviation is equal to the pixel range divided by six.

5. Method of raindrop detection according to one of claims 1 to 4, characterized in that the scaling of the captured images is done while the captured images are converted into images comprising a depth adapted to be processed and displayed.

6. Device for raindrop detection on a windscreen comprising:
   - a camera for being mounted onboard a vehicle and configured to view the windscreen on said vehicle, and
   - processing means configured to capture images from said camera and to detect edges in the captured images, and to generate at least one signal indicative of the presence of raindrop on said windscreen from information contained in the captured images.

characterized in that the processing means further comprise adaptive scale means configured to implement a method of raindrop detection according to one of claims 1 to 5.

7. Device for raindrop detection according to claim 6, in combination with a method of raindrop detection according to claim 5, characterized in that adaptive scale means are further configured to convert the captured images into images comprising a depth adapted to be processed and displayed.

8. Device for raindrop detection according to claim 7, characterized in that:
   - said camera provides 12-bits images,
said processing means are configured to process 8-bits images,
said device for raindrop detection device includes a display mean of 8-bits, and
said adaptive scale means are configured to scale the captured images pixels in function of the ambient light level while converting the 12-bits captured images into 8-bits processed and displayed images.
A. CLASSIFICATION OF SUBJECT MATTER

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)

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C. See patent family annex.

T later document published after the International filing date or priority date and not in conflict with the application but cited to understand the principal 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.

A document member of the same patent family

Date of the actual completion of the international search

13 October 2010

Date of mailing of the international search report

21/10/2010

Authorized officer

Sangiorgi, Massimo
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