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<p>(21) International Application Number: PCT/EP99/00300</p> <p>(22) International Filing Date: 15 January 1999 (15.01.99)</p> <p>(30) Priority Data:</p> <table border="0"> <tr> <td>98/00378</td> <td>15 January 1998 (15.01.98)</td> <td>FR</td> </tr> <tr> <td>PCT/EP98/05383</td> <td>25 August 1998 (25.08.98)</td> <td>EP</td> </tr> </table> <p>(63) Related by Continuation (CON) or Continuation-in-Part (CIP) to Earlier Application</p> <table border="0"> <tr> <td>US</td> <td>PCT/EP98/05383 (CIP)</td> </tr> <tr> <td>Filed on</td> <td>25 August 1998 (25.08.98)</td> </tr> </table> <p>(71) Applicant (for all designated States except US): HOLDING B.E.V. S.A. [LU/LU]; 69, route d'Esch, L-Luxembourg (LU).</p> <p>(71)(72) Applicants and Inventors: PIRIM, Patrick [FR/FR]; 56, rue Patay, F-75013 Paris (FR). BINFORD, Thomas [US/US]; 16012 Flintlock Road, Cupertino, CA 95014 (US).</p> <p>(74) Agent: PHELIP, Bruno; Cabinet Harlé & Phélip, 7, rue de Madrid, F-75008 Paris (FR).</p>	98/00378	15 January 1998 (15.01.98)	FR	PCT/EP98/05383	25 August 1998 (25.08.98)	EP	US	PCT/EP98/05383 (CIP)	Filed on	25 August 1998 (25.08.98)	<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p>Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>
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<p>(54) Title: METHOD AND APPARATUS FOR DETECTION OF DROWSINESS</p> <p>(57) Abstract</p> <p>In a process of detecting a person falling asleep, an image of the face of the person is acquired. Pixels of the image having characteristics corresponding to an eye of the person are selected and a histogram is formed of the selected pixels. The histogram is analyzed over time to identify each opening and closing of the eye, and characteristics indicative of the person falling asleep are determined. A sub-area of the image including the eye may be determined by identifying the head or a facial characteristic of the person, and then identifying the sub-area using an anthropomorphic model. To determine openings and closings of the eyes, histograms of shadowed pixels of the eye are analyzed to determine the width and height of the shadowing, or histograms of movement corresponding to blinking are analyzed. An apparatus for detecting a person falling asleep includes a sensor for acquiring an image of the face of the person, a controller, and a histogram formation unit for forming a histogram on pixels having selected characteristics. Also disclosed is a rear-view mirror assembly incorporating the apparatus.</p>											

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METHOD AND APPARATUS FOR DETECTION OF DROWSINESS

Binford

BACKGROUND OF THE INVENTION

1. Field of the Invention.

The present invention relates generally to an image processing system, and more particularly to the use of a generic image processing system to detect drowsiness.

2. Description of the Related Art.

It is well known that a significant number of highway accidents result from drivers becoming drowsy or falling asleep, which results in many deaths and injuries. Drowsiness is also a problem in other fields, such as for airline pilots and power plant operators, in which great damage may result from failure to stay alert.

A number of different physical criteria may be used to establish when a person is drowsy, including a change in the duration and interval of eye blinking. Normally, the duration of blinking is about 100 to 200 ms when awake and about 500 to 800 ms when drowsy. The time interval between successive blinks is generally constant while awake, but varies within a relatively broad range when drowsy.

Numerous devices have been proposed to detect drowsiness of drivers. Such devices are shown, for example, in U.S. Patent Nos. 5,841,354; 5,813,99; 5,689,241; 5,684,461; 5,682,144; 5,469,143; 5,402,109; 5,353,013; 5,195,606; 4,928,090; 4,555,697; 4,485,375; and 4,259,665. In general, these devices fall into three categories: i) devices that detect movement of the head of the driver, e.g., tilting; ii) devices that detect a physiological change in the driver, e.g., altered heartbeat or breathing, and iii) devices that

detect a physical result of the driver falling asleep, e.g., a reduced grip on the steering wheel. None of these devices is believed to have met with commercial success.

Commonly-owned PCT Application Serial Nos. PCT/FR97/01354 and PCT/EP98/05383 disclose a generic image processing system that operates to localize objects in relative movement in an image and to determine the speed and direction of the objects in real-time. Each pixel of an image is smoothed using its own time constant. A binary value corresponding to the existence of a significant variation in the amplitude of the smoothed pixel from the prior frame, and the amplitude of the variation, are determined, and the time constant for the pixel is updated. For each particular pixel, two matrices are formed that include a subset of the pixels spatially related to the particular pixel. The first matrix contains the binary values of the subset of pixels. The second matrix contains the amplitude of the variation of the subset of pixels. In the first matrix, it is determined whether the pixels along an oriented direction relative to the particular pixel have binary values representative of significant variation, and, for such pixels, it is determined in the second matrix whether the amplitude of these pixels varies in a known manner indicating movement in the oriented direction. In domains that include luminance, hue, saturation, speed, oriented direction, time constant, and x and y position, a histogram is formed of the values in the first and second matrices falling in user selected combinations of such domains. Using the histograms, it is determined whether there is an area having the characteristics of the selected combinations of domains.

It would be desirable to apply such a generic image processing system to detect the drowsiness of a person.

SUMMARY OF THE INVENTION

The present invention is a process of detecting a driver falling asleep in which an image of the face of the driver is acquired. Pixels of the image having characteristics corresponding to characteristics of at least one eye of the driver are selected and a histogram is formed of the selected pixels. The histogram is analyzed over time to identify each opening and closing of the eye, and from the eye opening and closing information, characteristics indicative of a driver falling asleep are determined.

In one embodiment, a sub-area of the image comprising the eye is determined prior to the step of selecting pixels of the image having characteristics corresponding to characteristics of an eye. In this embodiment, the step of selecting pixels of the image having characteristics of an eye involves selecting pixels within the sub-area of the image. The step of identifying a sub-area of the image preferably involves identifying the head of the driver, or a facial characteristic of the driver, such as the driver's nostrils, and then identifying the sub-area of the image using an anthropomorphic model. The head of the driver may be identified by selecting pixels of the image having characteristics corresponding to edges of the head of the driver. Histograms of the selected pixels of the edges of the driver's head are projected onto orthogonal axes. These histograms are then analyzed to identify the edges of the driver's head.

The facial characteristic of the driver may be identified by selecting pixels of the image having characteristics corresponding to the facial characteristic. Histograms of the selected pixels of the facial characteristic are projected onto orthogonal axes. These histograms are then analyzed to identify the facial characteristic. If desired, the step of identifying the facial characteristic in the image involves searching sub-images of the image until the facial characteristic is found. In the case in which the facial characteristic is the

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