Employee Alertness Monitoring Tutorial

Alasdair Macmillan

Overview

A common problem with some high-risk jobs is the issue of the alertness of the employees. Poor attention can cause accidents that can harm the employee or surrounding people. Typically in some scenarios a supervisor may keep an eye on employees to ensure that they do not fall asleep during dangerous tasks, such as operating heavy machinery.

There are many scenarios where manual supervision is impractical or impossible, and employees must monitor themselves to ensure that they do not fall asleep. The most common example of this are commercial drivers, who drive large vehicles for long periods of time. The employees may be working at night when there is very little noise and few distractions - ideal conditions to fall asleep. Currently, employees must rely on their own assessment of their wakefulness or company guidelines to schedule enough rest breaks to remain safe.

An employee alertness monitoring system is an automated attempt at reducing the risk of accidents related to poor employee attention. To properly solve the problem, it must detect when an employee is not paying attention, and alert them before they fall a sleep. If an employee falls asleep before a notification is sounded, then the system does not fulfil its goal. The alert should be an audio sound to ensure that the driver is properly alerted and woken up - a visual signal would most likely not be seen.

Previously attempted systems include using an electroencephalograph (EEG), a heartbeat sensor and a steering wheel monitor to attempt to assess when an employee is getting drowsy. These were ruled out for practical safety systems due to the invasive nature of the sensors: annoying safety equipment will likely be ignored or neglected by the employee.

Implementation

Currently, the most promising system uses a single camera vision system to detect user drowsiness. The camera is orientated towards the user's face,

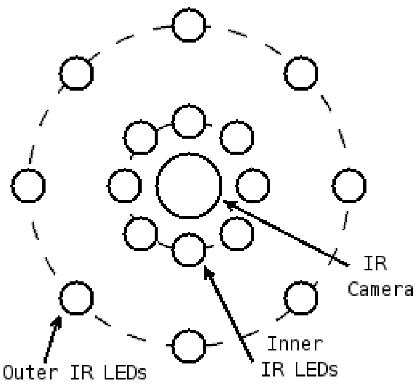

Figure 1: The camera system used to photograph the face and eyes.

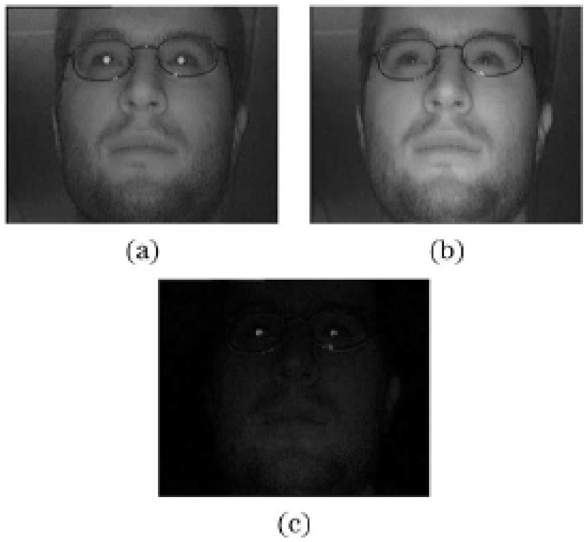

Figure 2: The pictures taken of the subject's face using (a) the inner IR ring, (b) the outer IR ring and (c) the difference between the two images (from Bergasa et al. [1]). Note the difference in eye intensity between the two images.

and uses two concentric rings of infra-red LEDS to attempt to identify the eyes. Each bank of LEDs are operated independently to obtain two different images of the user's face (see figure 1).

The first step in the system is to identify the user's eyes - these show the most symptoms of sleepiness. The system takes two different images using both of the concentric rings of infra-red LEDs. The picture from the larger ring gives more diffuse lighting, and the subject's eyes appear to be more black than the photo from the inner ring (see figure 2). More light is reflected from the eye from the inner ring due to the geometry of the solution (see figure 3). The photo from the inner ring produces better illumination on the eyes - this is subtracted from the first image to get the bright areas of difference. This is processed using the 8-connectivity filter to get circular bright areas, which define potential candidates for the subject's eyes. A classifier is then applied to determine the subject's eyes in the image.

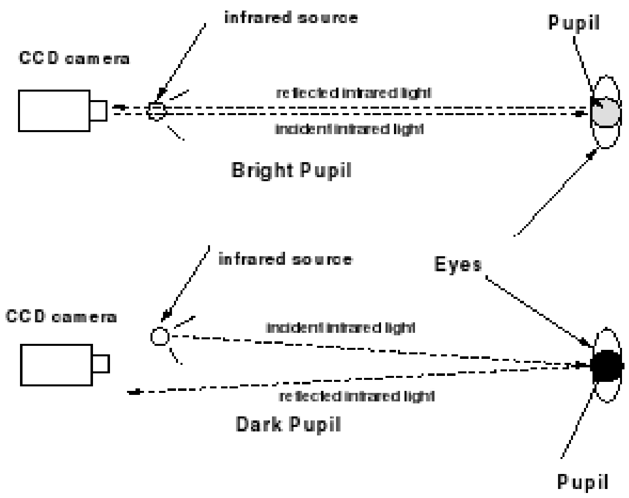

Figure 3: A geometric explanation of the difference in eye intensity in both photos. (From Ji et al. [2]).

Alertness Indicators

Once the subject's eyes can be identified, various heuristics can be used to determine the subject's wakefulness.

Percentage Eye Closure ("PERCOS")

This measurement stems from the observation that people who are feeling sleepy close their eyes more than alert people. The subject's eyes can be analysed to determine a measure of the ovalness of the eyes. A human eye is round, but appears to be increasingly oval when the eye lids start closing. To calculate the measure for percentage closure for each eye, the visible eye height in pixels is divided by the eye width in pixels.

Blink rate and duration

Another measurement that can be taken is the blink rate. A sleepier person would usually have a longer duration in which they have their eyes closed. Measuring the subject's blink rate over time can indicate problems with staying awake.

Gaze detection

A static gaze is usually a good indication in many applications that the subject is not paying attention - tasks that require situational awareness such as driving require the user to scan situations with their eyes to keep enough diverse visual data. It is usually not enough to stare in the direction of travel.

The pupil in the eye can be identified and tracked in the image; when movement ceases for a period of time, then this can be taken to be a sign that the subject is not paying attention. For a more in-depth study, see the work on gaze tracking by Ji et al. [2].

Alertness Calculation

From Bergasa et al. [1] we have empirical results for each heuristic used to calculate alertness:

Heuristic	Total Correct Percentage
PERCLOS	93.12%
Eye closure duration	84.37%
Blink Frequency	80%
Fixed gaze	95.62%

From Bergasa et al. we can see that some of the heuristics have better accuracy than others. The best results came from the percentage eye closure and the gaze detection; the greater error for other measurements is likely from greater human diversity rather from errors in experiment design.

Multiple heuristics can be combined together for greater accuracy. A suitable probabilistic learning algorithm such as a decision tree or a support vector machine can be used to train the system to estimate the subject's alertness. Using multiple heuristics typically gives a very accurate result, in the order of 98% accuracy for detecting inattention.

References

[1] L.M. Bergasa, J. Nuevo, M.A. Sotelo, R. Barea, and M.E. Lopez. Real-time system for monitoring driver vigilance. *IEEE Transactions on Intelligent Transportation Systems*, 7(1):63–77, 2006.

[2] Q. Ji and X. Yang. Real-time eye, gaze, and face pose tracking for monitoring driver vigilance. *Real-Time Imaging*, 8(5):357–377, 2002.