# Wearable Alertness Monitoring for Industrial Applications

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## Abstract

*A high level of alertness is one of the most important requirements for people working in dangerous environments. We follow the approach of using wearable computers as guards. In this paper we propose a wearable alertness monitoring guard using physiological measures - detecting eyelid closure, reaction time, head movements - to determine the wearer's actual alertness level.*

## 1. Introduction

Many people have to work permanently in dangerous environments. There are ongoing efforts to improve their protection, but an element of risk always remains [1]. We follow the approach of using wearable computers as guards, because the best limitation of the remaining risk is ones own alertness. Therefore, a wearable guard has to monitor the alertness of the wearer and warn him if his alertness falls below a critical level [2].

## 2. Previous Work

Psychological and neuropsychological theories of attention do not support a unitary concept of attention. Zomeren and Brower [3] divide attention tasks into two major components: Selectivity and Intensity. Further, Selectivity splits up into Focused Attention and Divided Attention. Intensity can be divided into Sustained Attention and Alertness (Tonic Alertness and Phasic Alertness). Tonic Alertness is a relatively stable level of attention, changing very slowly and involuntarily. Tonic changes of alertness are mostly explained from physiological, diurnal changes in the organism. Phasic Alertness is defined as the ability to enhance the activation level following a warning stimulus. In general, the difference between these two conditions serves as a measure for Phasic Alertness.

A popular method of detecting drowsiness/fatigue is the usage of a measure called PERCLOS (PERcent eyelid CLOSure). This measure tries to detect the percentage of eyelid closure over the pupil over time and reflects slow eyelid closures (droops) rather than blinks. A PERCLOS drowsiness metric was established in a driving simulator study as the proportion of time in a minute that the eyes are at least 80 percent closed [4].

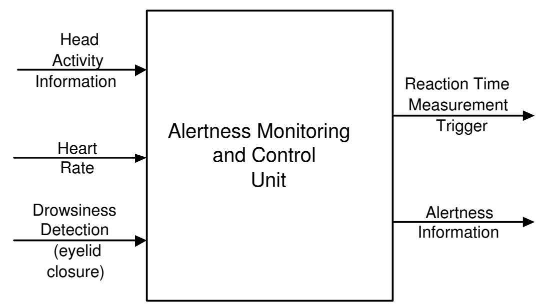


**Figure 1. Alertness monitoring and control unit (AMCU).**

## 3. Wearable Alertness Monitoring

Our concept of wearable alertness monitoring is based on the components *Heart-Rate Monitoring*, *Reaction Time Measurement*, *Video-based Drowsiness Detection*, and *Head Activity Detection*. Input and output signals of the Alertness Monitoring and Control Unit (AMCU) are shown in Figure 1.

### 3.1. Heart-Rate Monitoring

The heart-rate is monitored through a sensor in the earpiece. Due to the complex nature of a physiological signal like the heart-rate the individual average level is observed experimentally. The influence of decreasing and increasing levels used for alertness monitoring are described in the following section.

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### 3.2. Reaction Time Measurement

A simple explanation of the effect used by the AMCU is possible using the student-auditorium example. Keeping alertness during monotonous lessons is very difficult. Incidentally, a book may drop to the floor making a short very disturbing noise. This event guaranties that the students' alertness is very high in the following minutes.

Therefore, we propose a short and less frequent alertness reaction test during active work, in order to overcome monotonousness and fatigue of routine monitoring tasks. This is a simple auditory test with an irregular variation of the presentation of a warning stimulus and a random occurrence of the test within a certain amount of time. Confirmation is implemented by nodding, which is detected with motion sensors mounted on the helmet. The occurrence of the test is associated with a random counter value. A test is initiated whenever the counter has reached zero. The following weighted factors may increase or decrease this value and therefore delay or expedite the event. Counter increasing factors are working activity (head-movement, eyelid-activity) and a high positive differential heart rate; decreasing factors are long test reaction times and a long-time low stable heart rate level (adaptive personal level).

### 3.3. Video-based Drowsiness Detection

We follow the PERCLOS approach, which uses the information about the eye closure, rather than eye movement or blinks. PERCLOS is the proportion of time the eyes are closed 80 percent or more for a specified time interval [4] [5]. The eyelid closure can be obtained in real-time with an video based detection system using CMOS cameras attached to the protection helmet. Eye extraction and eye measurement is processed by the AMCU.

### 3.4. Head Activity Detection

Our approach for application specific activity pattern recognition rely on parameters that are more or less directly derived from the raw accelerometer data. The gravitation component can be used to determine the vertical head orientation. The change of speed is basis for motion analysis used for nodding and head activity detection. To simplify activity pattern recognition we introduced a classification of applications: *sitting application, walking application, operating application*.

People doing sitting jobs, for example observation tasks at assembly lines, move their head only marginally. Therefore, the alertness monitoring has to concentrate on eyelid closure detection and random reaction time measurement.

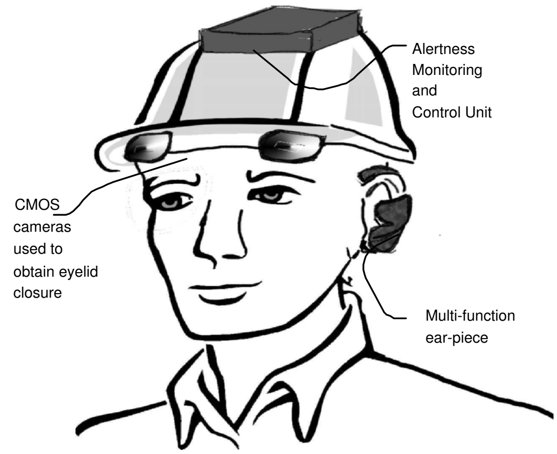


**Figure 2. Alertness monitoring helmet.**

## 4. Prototype

We are designing a prototype (see figure 2), which could be integrated in common industrial protection helmets. This wearable alertness guard consists of the AMCU including acceleration sensors, CMOS cameras used for eyelid closure detection, a multi-function ear-piece providing audible signals, a temperature sensor, and a heart-rate measurement sensor. There are also simple visual and audible warning indicators providing status information.

## References

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