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Development of Wearable Body Fatigue Evaluation and Awakening System

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Abstract

In this paper, a portable or wearable online monitoring system for eye movement and head motion parameters is designed. The eye movement tracking and head tracking are used to monitor the wearer for a long time, so as to determine the function expectation of the wearer in real time, and the lack of awakening condition under the setting conditions. In order to improve the level of arousal, people used sound, light and vibration stimulation to conduct state warning and physical stimulation. From the system, the wearer's brain fatigue state data can be monitored in a long time and continuous monitoring in the process of continuous operation and sleep deprivation, which can effectively improve the user's long time working ability and working state, and improve the vigilance and operation ability.

Keywords: Fatigue; Assessment; Wake up; Wearable; Bayesian network; Alertness.

1. Introduction

The change of arousal state is a systemic and systemic physiological change process. When the degree of awakening is reduced, the changes in physical function are manifested by the decrease of the contractile force, the

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decrease of the speed of movement, the decrease of the flexibility and coordination of the movement, the endurance of the movement and so on. The activity of the cerebral cortex will also change, which is characterized by reduced thinking activity, reduced thinking agility and so on. The decline and lack of awakening not only reduces the ability of people's work, reduces production efficiency, and is easily distracted, lacks accuracy, errors, accidents, and arousal. There is a close connection between state and safe production.

In the daily work, many jobs need a long time to maintain a higher vigilance, such as airport dispatchers, car drivers, medical workers, aerospace pilots, and military personnel carrying out special tasks. If such operators are mismanaged due to the drop-in vigilance, they may cause huge casualties and property losses. Therefore, how to detect fatigue quickly has become a very important research topic in the field of brain cognition.

At present, the methods of brain fatigue detection at home and abroad are mainly divided into two kinds of subjective detection and objective detection, of which the objective detection mainly includes the behavior feature detection (such as blinking, head action, mouth movement, etc.) and physiological characteristics detection (such as EEG, eye power, EMG, etc.); Subjective testing mainly includes evaluative detection and physiological response detection Physical reaction detection. The awakening methods mainly include physical regulation, chemical regulation and biological regulation. The related studies have shown that 80% of PRECLOS is related to the degree of human fatigue, and the specific wavelength of the light stimulation, the specific frequency and the loudness of the sound stimulation and vibration stimulation have a good effect on the increase of the degree of arousal.

In this paper, a portable and wearable online monitoring system for eye movement and head motion parameters is designed to monitor the wearer for a long time, to achieve the real time judgment of the wearer's awakening state, and to carry out early warning and physical stimulation to the people with insufficient awakening under setting conditions. The purpose of a high degree of awakening.

2. Overall Design

This system develops a wearable device for on-line assessment and real-time warning intervention of brain fatigue. The system function module is shown in Fig. 1. The components and software and hardware framework of the system are shown in Fig.2. Core is the core of the system, provides the functions of image acquisition, image processing and awakening. As the main device of image acquisition, CAM provides real-time image to processing core. The three-axis acceleration sensor is used to detect the instantaneous value of acceleration in each axis direction, LED, AUDIO and Display master. It should be used to promote stimulus output. The following is a detailed description of hardware structure design, software system design and human fatigue assessment module.

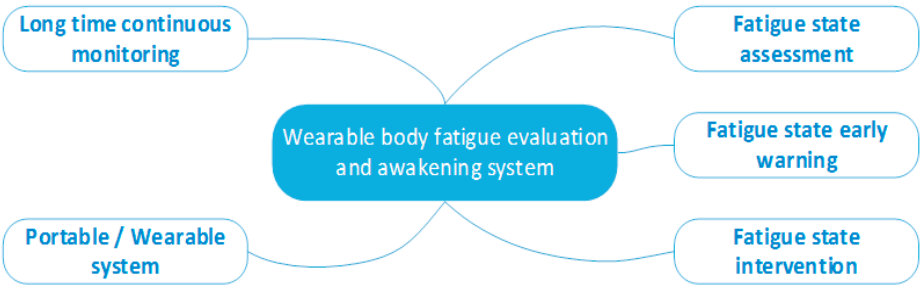

Figure. 1. System function diagram

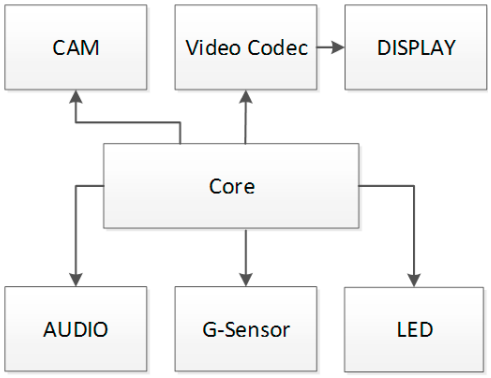

Figure. 2. Software and hardware framework

3. Design of Hardware Structure

The design prototype of this scheme takes intelligent glasses as a reference, dismantles the collection and output parts and the core parts of the processing, and the data transmission between them adopts the way of wired connection. As shown in Figure 3. In this design, the processing core is separated from the frame, and the frame is only used as the placement frame of the input and output equipment. Although this method increases the number of discrete modules of the system, it reduces the reliability of the system to a certain extent, but reduces the design difficulty and weight of the mirror frame, makes the core selection and design more flexible, and even can choose the ready miniaturized intelligent terminal as the core of the system (based on Android or Windows).

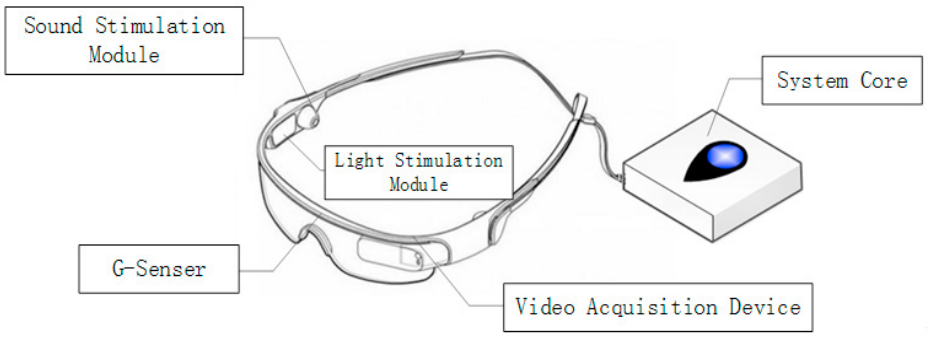

Figure. 3. Design drawings for hardware structure

4. Design of Software System

The software architecture of the system and the relationship between the subsystems are shown in Figure 4. The system collects the image data through the camera and collects the acceleration data of the equipment through the three-axis acceleration sensor. The data of the image and the acceleration sensor are preprocessed through filtering and converting to the core algorithm to determine the fatigue degree. If the result is up to the predefined fatigue vigilance value, the control result is controlled. The arousal stimulates the device to output the corresponding stimulation signal (sound stimulation, light stimulus, or video stimulus) until the stimulus response signal is input; the system continues to detect if the warning value of the preset fatigue degree is not reached.

Reference to the system design requirements, system requirements for video input, audio input and GPIO, there is no clear demand for GUI, so Linux or WinCE is not the best choice, Windows or Android can be selected, because both can make the system smaller, considering the consumption of system resources for the calculation of intensive equipment. Android is chosen as the core platform of the system.

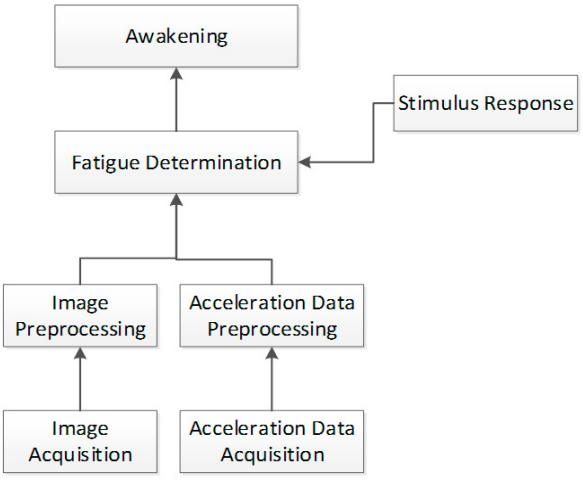

Figure. 4. Software architecture

5. Design of Body Fatigue Evaluation Module

This paper uses a linear classifier to learn a priori knowledge from the training samples to judge the degree of human fatigue. Then, the fatigue state is identified by the analysis of the changes in the eye feature parameters based on the Bayesian execution network.

The inference of fatigue state by Bayesian network is essentially a problem of obtaining a posteriori probability. It is a posterior distribution of fatigue state based on the observed variation characteristics of eye movements. In this problem, the observed eye variation features are called the evidence variable, which are recorded as E, and their values are recorded as E; and the degree of fatigue that needs to be calculated for the posteriori distribution, called the query variable, is recorded as Q, and the posterior distribution needs to be calculated as:

$$P(Q|E=e) \tag{1}$$

Bayesian network classifier is defined as: for probability distribution $p(x_1,x_2,\cdots,x_n,c)$, called use

$$\underset{c(x_1,x_2,\ldots,x_n)}{\arg\max}\ \{P(c|\pi_c)\prod_{i=1}^{n}(x_i|\pi_i,G_B)\} \tag{2}$$

The classifier that infers the variable C is a Bayesian network classifier, where the network structure composed of C, $x_1,x_2,\cdots,x_n$, π_c is the configuration of class variable C parent nodeπ_c, andπ_i is the configuration of Attribute Variable x_i parent node setπ_i

6. Conclusion and Prospect

Figure. 5. Experimental results

The system has been completed design and processing. At present, based on human experiments, see Figure 5. The experimental results show that the system can evaluate fatigue degree well and achieve certain awakening effect. At the end of this paper, the correspondence of eye movement, head motion parameters and the method of EEG awakening are studied and parameter mapping (calibration), so that the evaluation classification of this device is in accordance with the method of EEG evaluation and classification. The two assessment methods can be combined to further enhance the accuracy and effectiveness of sleep wakefulness assessment.

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