WORKERS SAFETY IN INDUSTRIES BY USING EEG AND IMU IN SAFETY HELMET

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Abstract

The paper aims to reducing the risk of injury and thus increase worker safety. Instead of using camera, Safety Helmet in order to track the head gestures and the brain activity of the worker to recognize anomalous behavior. It is known that head gesture and brain activity can reflect some human behaviors related to a risk of accident when using machine-tools. The Safety Helmet system is an inexpensive, non-intrusive, noninvasive, and non-vision-based system, which consists of an Inertial Measurement Unit (IMU) and EEG. A haptic device, such as vibrotactile motor, is integrated to the helmet in order to alert the operator when computed risk level reaches a threshold. Once the risk level of accident breaks the threshold, a signal will be sent wirelessly to stop the relevant machine tool or process. Information extracted from Safety Helmet is used for computing risk of an accident (a safety level) for preventing and reducing injuries or accidents.

Keywords: Electroencephalography (EEG), DC Motor, Inertial Measurement Unit (IMU), RF Transmitter, RF Receiver, Safety Helmet (SH).

1.INTRODUCTION

Workers when working in industries for more time some mental states, such as fatigue, stress or sleepiness are known to increase the potential of accidents in industry, therefore could decrease productivity and increase the cost of healthcare if the potential accident occurs. The highest rate of industrial accidents is usually found among shift workers due to fatigue or extended work hours. Fatigue levels are not easily quantified; therefore it is difficult to identify the effect of fatigue on accident and injury rates. However, fatigue is still considered as a factor with 20% contribution to reported accidents and incidents across all sectors. When using machine tool, the risk of injury increases due to disturbance, lapse in concentration, vigilance decline, and neglect of the risk during prolonged use. The guiding objective of this project is to develop a device able to recognize abnormal behaviors of workers which endanger safety and health. This is an inexpensive, non-intrusive and non-invasive Safety Helmet system, which is non-vision-based. The SH includes mechanical components, electronic hardware for sensing human behaviors, an embedded real-time artificial intelligence module, a wireless transmission to communicate with the machine tool, and an electronic medical records. This project aims at evaluating anomalous behaviors and user's habits inside different workplaces. The data coming from the SSH could be saved in an electronic medical record and then be used in order to increase safety or even productivity via diagnostic aid software and real-time biofeedback.

Block Diagram:

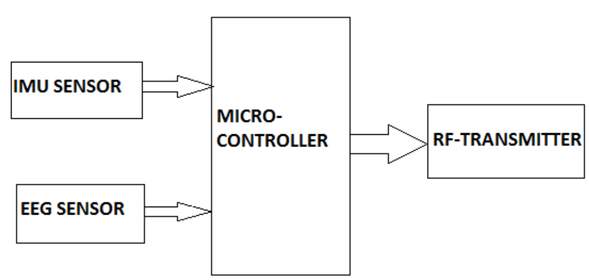


Figure 1 Transmitter section

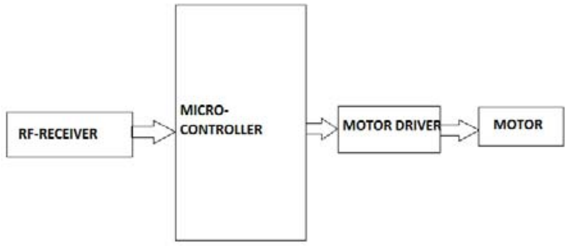


Figure 2 Receiver Section

2.RELATED WORK

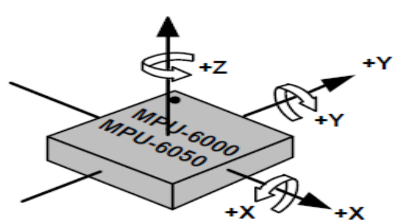
In contrast with video-based monitoring devices, wearable EEG and IMU sensors are chosen for risk level analysis, since they are lighter, less expensive and could be integrated to any safety clothing. This section explains the review of IMU and EEG technology.

A. The IMU (Inertial Measurement Unit):-

Is a sensor that hosts two types of sensor. The IMU sensor is a special one designed to combine the features of an accelerometer and gyroscope in order to display complete information about the acceleration, position, orientation, speed.

ACCELEROMETER:-

An accelerometer sensor is designed to measure the acceleration and tilt. The accelerometer sensor measure acceleration in two different units including meters per second squared, or when the acceleration felt like a weight, in G-forces. Inside this tiny sensor is a small system that bends when a momentum or gravity force is applied. The amount of bend has a proportional value of the output signal.



Orientation of Axes of Sensitivity and Polarity of Rotation

GYRO SENSOR:-

The gyroscopic sensor measures the angular velocity and orientation. The gyroscope sensor is inexpensive and measures in degrees per second or revolutions per second the angular velocity. Any human motion can be divided into a series of displacements of the torso or the limbs. An IMU sensor is a device able to measure the moving object's acceleration, velocity, orientation, using a combination of accelerometers, gyroscopes and magnetometers. Consequently, the body mounted IMU is able to measure the body parts movement. With the development of semiconductor, miniature IMU with low cost and power consumption, are widely applied in motion measurement and tracking gait analysis inertial navigation and positioning as a wearable solution, and even in robotic system using artificial intelligence as an embedded component.

Helmet-mounted IMU sensors in the SSH are exploited to recognize head gesture and some activities as in the application described in using the DTW algorithm in the gestures and activities are classified using patterns in order to determine the human's intention, and then used for risk level analysis.

B. Electroencephalography (EEG)

EEG used to detect mental states. The EEG signal is a voltage signal that arises from synchronized neural activity, that is, the coordinated firing of millions of neurons in the brain. It can be measured by non-invasively placing an electrode on or near the scalp, and for greater accuracy, by implanting an electrode in the skull. As noted by mostow etal synchronized neural activity varies according to development, mental state, and cognitive activity, and the EEG signal can measurably detect 5 variation. For example, rhythmic fluctuations in the EEG signal occur within several particular frequency bands, and the relative level of activity within each frequency band has been associated with brain states such as focused attentional processing, engagement, and frustration which in turn are important for and predictive of learning.

In industrial environment, repeated working activities, noise level, and shift change affect the worker physiological status, his or her state of mind and then possibly result in fatigue, lapses of concentration, vigilance decline, and sleepiness. These abnormal physiological statuses are known as potential threats to the human health and factors of accidents and injuries. Mental state represents an important factor for characterizing a worker's physiological status. For example, mental state should be related to the stress caused by a finger or hand jammed in a machine. When detecting stress, the machine should be shut down immediately. Consequently, monitoring the mental states of operators could identify potential and current risk, and help.

Helmet working based on EEG signal

The safety helmet is the footing of the system. The electronic board is fixed in the helmet.

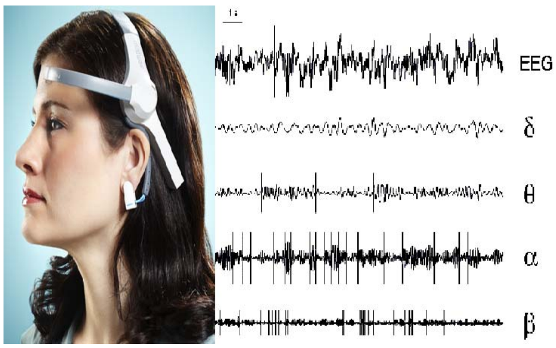


Figure 3 EEG Signal Output

Type	Frequency(Hz)	Use
∂	<4	Occur during sleep, coma
θ	4-7	Correlated with emotional stress
α	8-12	Mental imagery
β	12-36	Mental activity

Table 1 Brain Waves

Transfer of EEG signal to controller

The Safety Helmet monitors brainwaves and head motion in order to characterize human behavior in the context of a specific workflow within a workspace. Extraction of intelligible information from raw data is done by an artificial intelligence algorithm such as those used in the risk level is then computed on the basis of previous experience and surrounding tools or processes. The sensing data coming from both IMU of EEG are processed in order to find head gesture and mental state. Therefore, this information is analyzed in order to compute a risk level. The risk level could be associated to any injury with a machine tool or a risk of accident coming from an industrial process.

EEG signal capturing classification and processing

Using EEG to detect mental states The EEG signal is a voltage signal that arises from synchronized neural activity, that is, the coordinated firing of millions of neurons in the brain. It can be measured by non-invasively placing an electrode on or near the scalp, and for greater accuracy, by implanting an electrode in the skull. As noted by mostow et al synchronized neural activity varies according to development, mental state, and cognitive activity, and the EEG signal can measurably detect 5 variation. For example, rhythmic fluctuations in the EEG signal occur within several particular frequency bands, and the relative level of activity within each frequency band has been associated with brain states such as focused attentional processing, engagement, and frustration which in turn are important for and predictive of learning .

3. APPLICATIONS

1. In Industries for worker and machine safety.
2. In Driving to prevent accidents.
3. On Constructions site.

4. CONCLUSION

This system is centered on a Safety Helmet containing both IMU and EEG sensors. With the realized experiment, we show that using an accelerometer can identify the head motion caused by fatigue and sleepiness of workers. In the context of this work, the normalized acceleration variance of X-axis and Z-axis could be adopted as indexes to differentiate the risky motion from others. These data could be fused with the EEG signal to enhance the accuracy of the risk estimate. Three actions are suggested as a function of the evaluated risk level:

1) No action to perform (low risk),
2) Alert the user via haptic biofeedback such as vibration motor (medium risk) and
3) Shut down the machine tool if the risk level breaks the high risk level.

5. REFERENCES

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