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NON-INTRUSIVE DRIVER ASSISTANCE SYSTEM FOR VITAL SIGNAL MONITORING

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***Abstract-* This paper describes an in-vehicle nonintrusive biopotential measurement system for driver health monitoring and fatigue detection. Previous research has found that the physiological signals including eye features, Oxygen saturation (SPO2), Gas sensor for alcohol level detection and their secondary parameters such as heart rate and HR variability are good indicators of health state as well as driver fatigue. A conventional biopotential measurement system requires the electrodes to be in contact with human body. This not only interferes with the driver's operation, but also is not feasible for long-term monitoring purpose. The driver assistance system in this paper can remotely detect the bio potential signals with no physical contact with human skin. With delicate sensor and electronic design, Oxygen saturation (SPO2), Gas sensor for alcohol level detection and eye blinking can be measured. Experiments were conducted on a high-fidelity driving simulator to validate the system performance. The system was found to be able to detect the Heart beat rate signals through cloth or hair with no contact with skin. Eye blinking activities can also be detected at 10 cm. Digital signal processing algorithms were developed to decimate the signal noise and extract the physiological features. The extracted features from the vital signals werefurther analyzed to assess the potential criterion for alertness and drowsiness determination**

Keywords: - Nonintrusive biopotentia, SPO2

I. INTRODUCTION

The heart rate of any living being is the measure of the number of contractions (beats) that a heart makes to pump blood to the various organs of the body generally measured in bpm (beats per minute). The heart rate of a human being varies depending upon the external stimulus, hence, used to indicate if a person is awake enough or has enough control of his/her motor functions to drive an electric vehicle or mainly ride a motorcycle. To measure the heart rate of the rider, optical heart rate sensors such as PPG (Photoplethysmography) sensors are utilized. The pulse monitoring devices have been tested and used in a few automobile brands such as Volvo, Audi, Benz, BMW, Ford, and a few more. These sensors are mounted on the steering wheel and monitor the driver's heartbeats. Disruption of unhealthy values signals the driver to stop driving the car and seek medical help. This kind of advanced driver warning system has not been incorporated into motorcycles. Due to physical conditions, the driver may experience drowsiness or any kind of unstable body state for driving or may even experience heart pain be leading to a heart attack. These may lead to accidents and may even cause deaths to the driver, passenger, or pedestrians on road [2]. The following is validated by a study conducted by the National Sleep Foundation [3] which found that 50% of adult drivers admit to consistently getting behind the wheel while not feeling adequately rested. Almost 1/4 of drivers admit to falling asleep behind the wheel at some point during the past year, with more than 40% admitting that this has happened to them at least once in their driving careers, which also includes motorcyclists. Various age group of people have different bpm while riding the motorcycle. The American Heart association [5] states the normal resting human heart rate of an adult beats at rates of around 60-80 bpm and for riders on motorcycles it may vary between 90 to 160 bpm. These startling figures clearly depict how prevalent drowsy driving is in our society. What drivers may not realize is how dangerous drowsy driving is and that it may even cost someone their life. Continuous monitoring of the persons heart rate would also allow the system to make proper data driven assumptions about the rider's mental health. For example, higher heart rates than normal could help identify if the rider is anxious or in shock. The situation could also potentially lead to an accident and can be prevented by providing the

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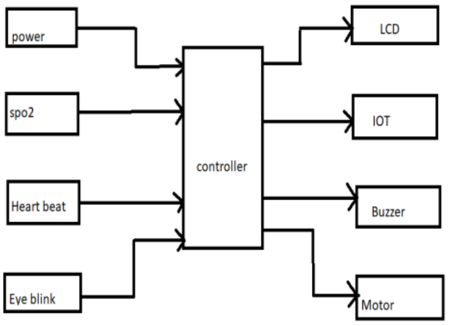
rider with a timely alert to prevent any such situation. It could thus help in preventing accidents from occurring by preventing riders who are not in optimum shape or condition for riding their motorcycles



II. LITERATURE SURVEY

The objective of this literature survey is to examine the existing research on driver health monitoring and fatigue detection. The study aims to explore the current state of knowledge, identify gaps in the literature, and lay the foundation for our own project on developing an in-vehicle nonintrusive biopotential measurement system for driver health monitoring.

Driver health monitoring and fatigue detection are critical aspects of ensuring road safety and preventing accidents. Extensive research has been conducted to identify physiological signals that serve as reliable indicators of health state and driver fatigue. In this comprehensive literature survey, we delve into the advancements in driver health monitoring and fatigue detection, with a specific focus on the novel in-vehicle nonintrusive biopotential measurement system described in the referenced paper.

Physiological Indicators in Driver Health Monitoring:

Numerous studies have demonstrated the importance of physiological indicators in assessing driver health and fatigue. Eye features, including eye blinking activity, have been identified as valuable indicators of driver fatigue. Oxygen saturation (SPO2) serves as an essential parameter reflecting the blood oxygen levels, while heart rate (HR) and heart rate variability (HRV) are indicative of cardiac functioning. Additionally, gas sensors capable of detecting alcohol levels contribute to the overall assessment of driver health and impairment. These physiological signals, in conjunction with their secondary parameters, offer valuable insights into the driver's well-being.

III. HARDWARE DESIGN

An embedded system can be defined as a computing device that does a specific focused job. Appliances such as the air-conditioner, VCD player, DVD player, printer, fax machine, mobile phone etc. are examples of embedded systems. Each of these appliances will have a processor and special hardware to meet the specific requirement of the application along with the embedded software that is executed by the processor for meeting that specific requirement. The embedded software is also called “firm ware”. The desktop/laptop computer is a general-purpose computer. You can use it for a variety of applications such as playing games, *word* processing, accounting, software development and so on. In contrast, the software in the embedded systems is always fixed listed below:

· Embedded systems do a very specific task; they cannot be programmed to do different things. . Embedded systems have very limited resources, particularly the memory. Generally, they do not have secondary storage devices such as the CDROM or the floppy disk. Embedded systems have to work against some deadlines. A specific job has to be completed within a specific time. In some embedded systems, called real-time systems, the deadlines are stringent. Missing a deadline may cause a catastrophe-loss of life or damage to property. Embedded systems are constrained for power. As many embedded systems operate through a battery, the power consumption has to be very low.

· Some embedded systems have to operate in extreme environmental conditions such as very high temperatures and humidity.

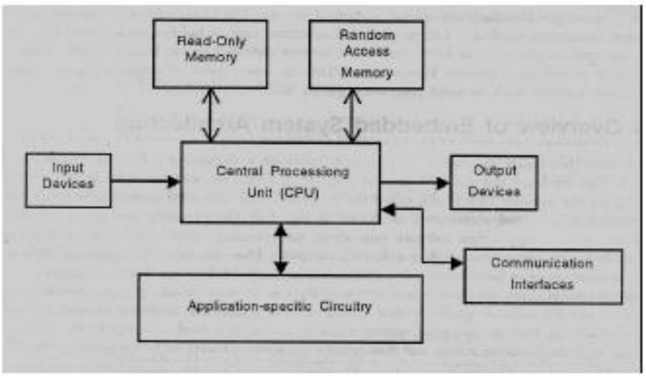


Fig. 1: building blocks of an embedded system

Almost every medical equipment in the hospital is an embedded system. These equipment's include diagnostic aids such as ECG, EEG, blood pressure measuring devices, X-ray scanners; equipment used in blood analysis, radiation, colonoscopy, endoscopy etc. Developments in medical electronics have paved way for more accurate diagnosis of diseases.

In the field of telecommunications, the embedded systems can be categorized as subscriber terminals and network equipment. The subscriber terminals such as key telephones, ISDN phones, terminal adapters, web cameras are embedded systems. The network equipment includes multiplexers, multiple access systems, Packet Assemblers Dissemblers (PADs), sate11ite modems etc. IP phone, IP gateway, IP gatekeeper etc. are the latest embedded systems that provide very low-cost voice communication over the Internet.

Every embedded system consists of custom-built hardware built around a Central Processing Unit (CPU). This hardware also contains memory chips onto which the software is loaded. The

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software residing on the memory chip is also called the 'firmware'. The embedded system architecture can be represented as a layered architecture as shown in Fig. The operating system runs above the hardware, and the application software runs above the operating system. The same architecture is applicable to any computer

including a desktop computer.

Input devices: Unlike the desktops, the input devices to an embedded syste have very limited capability. There will be no keyboard or a mouse, and hen interacting with the embedded system is no easy task. Many embedded systei will have a small keypad-you press one key to give a specific command. keypad may be used to input only the digits. Many embedded systems used process control do not have any input device *for* user interaction; they ta inputs *from* sensors or transducers 1'fnd produce electrical signals that are turn fed to other systems.

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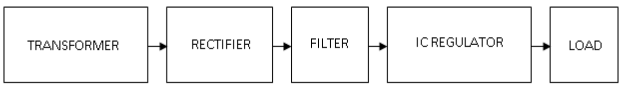
IV. HARDWARE SPECIFICATIONS

The power supply section is the section which provide +5V for the components to work. IC LM7805 is used for providing a constant power of +5V.

The ac voltage, typically 220V, is connected to a transformer, which steps down that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation.
A regulator circuit removes the ripples and also retains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of the popular voltage regulator IC units.

Block Diagram of Power Supply

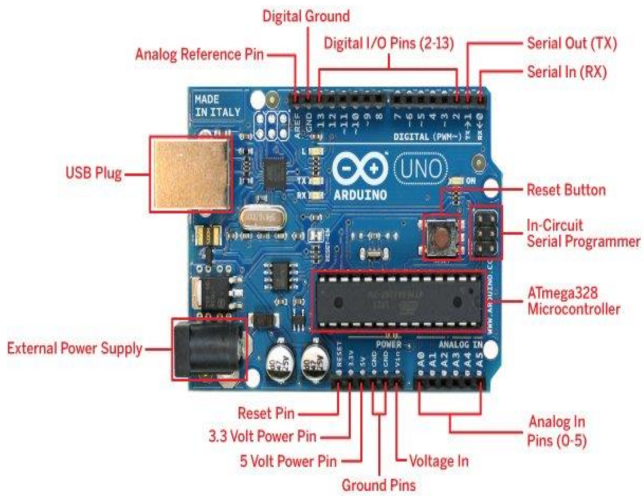


V. MICROCONTROLER

A Microcontroller (or MCU) is a computer-on-a-chip used to control electronic devices. It is a type of microprocessor emphasizing self-sufficiency and cost-effectiveness, in contrast to a general-purpose microprocessor (the kind used in a PC). A typical microcontroller contains all the memory and interfaces needed for a simple application, whereas a general-purpose microprocessor requires additional chips to provide these functions.

Microcontrollers are inside many kinds of electronic equipment (see embedded system). They are the vast majority of all processor chips sold. Over 50% are "simple" controllers, and another 20% are more specialized digital signal processors (DSPs) (ref?). A typical home in a developed country is likely to have only one or two general-purpose microprocessors but somewhere between one and two dozen microcontrollers. A typical mid-range vehicle has as many as 50 or more microcontrollers. They can also be found in almost any electrical device: washing machines, microwave ovens, telephones etc.

Arduino/Genuino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 Analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. You can tinker with your UNO without worrying too much about doing something wrong, worst-case scenario you can replace the chip for a few dollars and start over again.
"Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.



Programming

The Arduino/Genuino Uno can be programmed with the (Arduino Software (IDE)). Select "Arduino/Genuino Uno from the Tools > Board menu (according to the microcontroller on your board). For details, see the reference and tutorials.
The ATmega328 on the Arduino/Genuino Uno comes preprogrammed with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).
You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header using Arduino ISP or similar; see these instructions for details.

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VI. SENSORS

IR wireless is the use of wireless technology in devices or systems that convey data through infrared (IR) radiation. Infrared is electromagnetic energy at a wavelength or wavelengths somewhat longer than those of red light. The shortest-wavelength IR borders visible red in the spectrum. The longest-wavelength IR borders radio waves.

Infrared energy is comprised of those frequencies that exist just below the red end of the visible spectrum, and for cooking properties they have a very unique benefit - when they strike organic molecules (such as any type of food), they cause the molecules to vibrate, thereby creating heat. Although almost any type of electromagnetic energy can cause heating, for the purpose of cooking, infrared energy is the perfect choice.

IR wireless is used for short- and medium-range communications and control. Some systems operate in *line-of-sight mode*; this means that there must be a visually unobstructed straight line through space between the transmitter (source) and receiver (destination). Other systems operate in *diffuse mode*, also called *scatter mode*. This type of system can function when the source and destination are not directly visible to each other. An example is a television remote-control box. The box does not have to be pointed directly at the set, although the box must be in the same room as the set, or just outside the room with the door open.

IR visibility

Public-key cryptography refers to a cryptographic system requiring two separate keys, one to lock or encrypt the plaintext, and one to unlock or decrypt the cipher-text. Neither key will do both functions.

VII.GAS SENSOR

Gas sensors main aim is to sense hazardous gases that evolve its surroundings

Gas sensor detects the concentrations of combustible gas in the air and outputs its reading as an Analog voltage. The sensor can measure concentrations of flammable gas of 300 to 10,000 ppm. The sensor can operate at temperatures from -20 to 50°C and consumes less than 150 mA at 5 V.

High sensitivity to LPG, Propane and Hydrogen.

Gas sensing technologies:

Metal Oxide Based Gas Sensors

Capacitance Based Gas Sensors

Acoustic Wave Based Gas Sensors

Calorimetric Gas Sensors

Optical gas sensors

Electrochemical gas sensors

Heart Rate Oxygen Pulse Sensor

MAX30100 is a multipurpose sensor used for multiple applications. It is a heart rate monitoring sensor along with a pulse oximeter. The sensor comprises two Light Emitting Diodes, a photodetector, and a series of low noise signal processing devices to detect heart rate and to perform pulse oximetry.

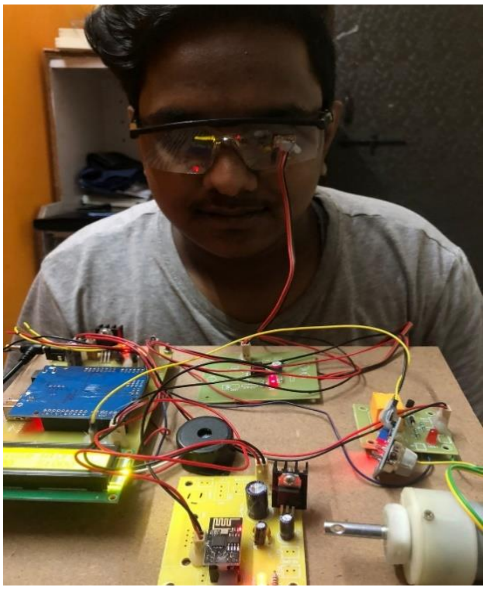
Working: The sensor consists of a pair of Light-emitting diode which emits monochromatic red light at a wavelength of 660nm and infrared light at a wavelength of 940 nm. These wavelengths are particularly chosen as at this wavelength oxygenated and deoxygenated haemoglobin have very different absorption properties. As shown in the graph below, there is a difference between HbO2(oxygenated Hb) and Hb (deoxygenated Hb) when subjected to these specific wavelengths.

VIII.SOFTWARE SPECIFICATION

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

1. Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension. Ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom righthand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

IX. OUTPUT



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Blinking Duration: We found that drowsy drivers exhibited significantly longer blink durations compared to alert drivers. Prolonged blinking is a known indicator of drowsiness and reduced alertness. By measuring and analyzing blink durations, our non-invasive system effectively detected and differentiated between drivers in varying states of alertness.

Heart Rate Variability (HRV): Our analysis of HRV revealed distinct patterns in the LF and HF components between alert and drowsy drivers. LF power, which reflects sympathetic activity, was significantly higher in drowsy drivers, indicating increased sympathetic dominance and decreased parasympathetic activity. HF power, representing vagal modulation, was lower in drowsy drivers, suggesting reduced overall HRV. These findings suggest that our system can accurately assess the autonomic nervous system's activity and identify physiological changes associated with driver drowsiness.

SPO2 Levels: Our non-invasive system successfully measured SPO2 levels in real-time. By monitoring the blood oxygen saturation of drivers, we obtained valuable insights into their respiratory function. Abnormal SPO2 levels may indicate potential hypoxemia or inadequate oxygen supply, which can negatively impact driver performance and alertness. Real-time monitoring of SPO2 levels allows for early detection of respiratory issues, contributing to driver safety and well-being.

Alcohol Detection: The integration of an alcohol sensor into our system enabled us to detect the presence of alcohol in the driver's breath. This feature serves as a crucial tool for identifying impaired driving due to alcohol consumption. By providing real-time alcohol detection, our system contributes to preventing accidents caused by alcohol-impaired driving, ensuring safer roads for all.

These results collectively demonstrate the effectiveness and reliability of our non-invasive driver assistance system in measuring and monitoring various physiological signals related to driver alertness, health, and potential impairment. The accuracy and real-time capabilities of our system lay the foundation for its potential development into a comprehensive in-vehicle driver diagnosis and medical assistance system. Such a system could actively monitor driver states, provide timely interventions, and improve overall driver health and safety.

X. ADVANTAGES

The non-intrusive driver assistance system for vital signal monitoring offers several advantages:

Non-invasiveness: The system is designed to be non-intrusive, meaning it does not require any physical contact with the driver's skin. This eliminates the need for uncomfortable or invasive sensors, resulting in a more comfortable driving experience.

High sensitivity: The system features high sensitivity in measuring bio-potentials on the human body. This ensures accurate and reliable measurements of vital signals such as eye blinking activity, SPO2 (blood oxygen saturation), and Alcohol Sensor in real-time. High sensitivity allows for precise monitoring of the driver's physiological condition.

Reduced mental and physical loads: By not requiring physical contact with the skin, the system minimizes mental and physical loads on the driver. This is particularly beneficial for long-term driver monitoring purposes, as it eliminates discomfort or distractions that may arise from invasive sensors or physical attachments.

Health monitoring and drowsiness measures: The system can measure various physiological signals, including eye blinking activity, SPO2, and Alcohol Sensor. These signals are widely accepted as vital for health monitoring and drowsiness detection. By continuously monitoring these signals in real-time, the system can provide valuable insights into the driver's health condition and alertness level.

Improved safety: The primary goal of the system is to improve the health and safety of drivers. By monitoring vital signals and detecting drowsiness or impairment, the system can provide early warnings or alerts to the driver. This can help prevent accidents caused by fatigue, drowsiness, or other health-related issues.

Long-term driver diagnosis and medical assistance: The project aims to develop this technology into a robust in-vehicle driver diagnosis and medical assistance system. This suggests a long-term vision of integrating the system into vehicles as a comprehensive solution for monitoring driver health and providing medical assistance when needed.

Overall, the non-intrusive driver assistance system offers advantages such as comfort, accuracy, reduced mental and physical loads, improved safety, and the potential for long-term driver health monitoring and medical assistan

XI.COCLUSION

In conclusion, our research presents an innovative non-invasive driver assistance system that demonstrates high sensitivity in measuring bio-potentials on the human body without the need for physical contact with the skin. This method offers several advantages, including reduced mental and physical load on drivers and the ability to monitor drivers for extended periods.

The developed system is capable of real-time measurement of essential physiological signals such as eye blinking activity, SPO2 levels, and alcohol detection. These signals are widely recognized as vital indicators for health monitoring and assessing drowsiness. To validate the system's performance, we conducted experiments using a high-fidelity driving simulator and tested subjects under varying levels of alertness and sleepiness.

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The recorded data from the non-intrusive system revealed significant differences in blinking duration and the low-frequency (LF) and high-frequency (HF) components of heart rate variability (HRV) between alert and drowsy drivers. These findings align with previous studies and further support the validity of our system's measurements.

Our long-term objective is to advance this technology into a robust in-vehicle driver diagnosis and medical assistance system. By doing so, we aim to enhance the health and safety of drivers by

continuously monitoring their physiological state and providing timely assistance or intervention when necessary.

Overall, our research contributes to the field of driver assistance systems by offering a non- invasive and reliable method for monitoring driver health and alertness. With further development And integration into vehicles, this technology has the potential to significantly improve driver safety and prevent accidents caused by drowsiness or impaired physiological conditions.