Wireless Biosensing Network for Drivers' Health Monitoring

Abstract—**Biosensors integrated into the vehicle controller area network are used for detecting symptoms such as anxiety, pain, and fatigue that may affect driving safety. The proposed system provides a flexible option for implementation in a diverse range of mass-produced automotive accessories without affecting the driver's movement.**

I. Introduction

Onboard diagnostics (OBD) systems become an integral part of modern motor vehicles for continuous assessment of vehicle system health [1]. Additional features for monitoring various health parameters of the driver can be accomplished through connection of appropriate biosensors such as that deployed in a smart home environment [2]. Any anomaly detected will trigger an alarm and emergency response can be initiated through a telemedicine link [3]. The implementation is particularly suited for automotive consumer electronics marketing in response to the mandatory inclusion of eCall system in the EU by October 2017 [4] that does not entail retrofitting of any electronics components.

This paper describes an implementation approach that utilizes the integrated controller area network (CAN bus) of a motor vehicle for interconnection of different sensors to support both continuous and continual health monitoring of various health signs of a driver. Its primary function is to trigger an alert in the event of detecting any abnormal readings. These are therefore more suitable for consumer-grade health monitoring due to their minimal on-board circuitry.

II. Controller Area Network

The sensing network consists of different non-invasive sensors that require each sensor to operate independently while collecting measurements and forward them to the OBD for processing. Continual health monitoring of parameters such as blood glucose and pressure do not require a continuous power source that can run on harvested power for communication. On receiving data from the biosensors; the system will commence anomaly event detection. The biosensor that picks up abnormal reading will be assigned with a higher transmission priority and automatically sends an alarm to the response center [5]. One of the main functions of the OBD is to control the state of the software-selectable CAN interface and detects anomaly based on data received from the biosensing network with specifications summarized in Table I.

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TABLE I
SENSING NETWORK PARAMETERS

Network	Parameter	Specification
Biosensors Driver Health (Wearable)	Transmission Power Packet Size Packet Inter-arrival Time Nominal BER	2 dBm 512 Bytes > 10 ms 10^{-4}
Controller Area Network (CAN)	Transmission Power Packet Size Data Rate Network Bandwidth Center frequency	10 dBm 8 192 Bytes 11 Mb/s 4 MHz 2.4 GHz

III. Consumer Health Automotive Accessories

A. Biosensors placement

The most economical means of installation without entailing any physical alteration to the motor vehicle is to install wireless sensors on various automotive accessories depending on the health signs being monitored, these include seat pads, steering wheel covers and wearables such as smart cloths and watch [6]. Our preliminary study aims at providing general health assessment for back pain and fatigue.

B. Implementation

The initial deployment studies back pain caused by prolonged driving that involves the use of three sensors attached to the upper trunk. Two of them were attached bilaterally to the acromions and the last one was attached to the spinous process of the seventh cervical spine (C7). A rigid lumbar cluster was positioned at L1 spinous process to define the orientation of lower trunk. In addition, sensors are attached from proximal to distal, down from knee, leg, ankle and to foot. The knee sensor was placed over the lateral epicondyle of femur. The leg sensor was placed at about distal on-third of the most lateral aspect of leg. The ankle sensor was placed at lateral malleolus. Finally, the foot sensor was placed at the second metatarsal head. Driver's leg length was measured from ASIS to medial malleolus for the calculation of the hip joint center [7]. The sensors continually track the driver's movement and the collected data is forwarded to the OBD for analysis.

Fig. 1 Posterior view of driver with biosensors and EMG electrode placements

C. Performance evaluation

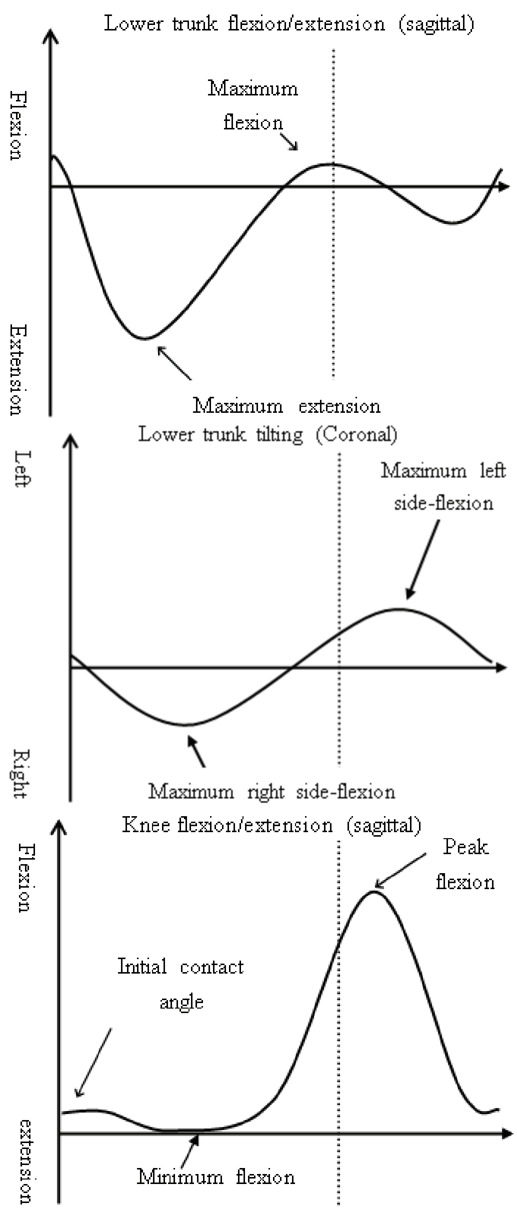

Fig. 3 Selected parameters for electromyographic analysis

The muscle activities of bilateral erector spinae and multifidus were monitored by surface electromyography (EMG). Electrodes for erector spinae were attached bilaterally to the greatest convexity of the muscle bulk by palpation [8]. Skin impedance for each pair of electrodes was below 50 kΩ.

The peak and mean values of EMG of erector spinae and multifidus were analyzed, EMG signals of each muscle were recorded for 5 seconds.

D. Network optimization

The CAN bus is shared by different subnetworks within the motor vehicle including infotainment, vehicle system health diagnosis along with the driver health monitoring system. Since the biosensor network consists of sensor nodes that sense changes in the vehicle cabin which enables real-time monitoring of Point of Care (PoC) as shown in Fig. 4.

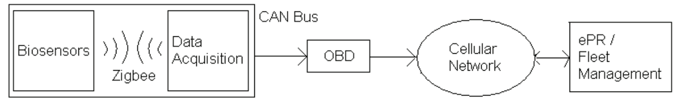

Fig. 4 Network architecture

A scalable network is optimized using a prognostics approach [9], [10] whose transmission characteristics are shown in Fig. 5 where E_b/N_o is evaluated for the sensing network.

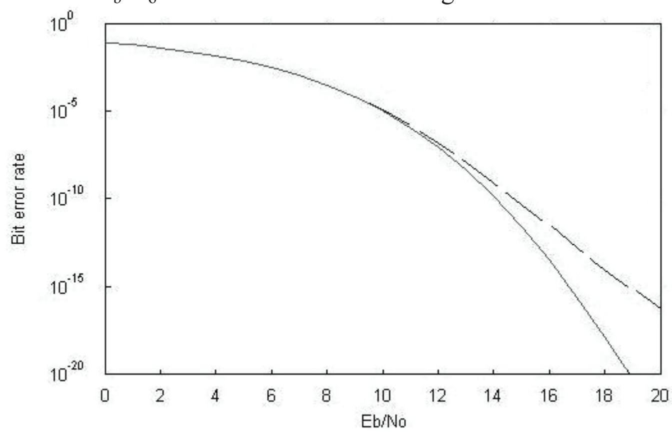

Fig. 5 Network performance evaluation

IV. Conclusions

Wireless sensors are connected via a motor vehicle onboard diagnosis system that monitors various health signs using a prognostics methodology. Such implementation is particularly suited for the mass-produced consumer healthcare industry due to minimal additional hardware requirements and ease of installation without affecting other parts of the vehicle.

References

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