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ASPECTS CONCERNING DRIVERS MONITORING HEALTHCARE SYSTEMS

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Abstract: *This paper deals with the methodology of creating a new intelligent system for monitoring the vital functions of the driver to avoid a possible accident. In this paper a short presentation was made concerning the achievements in the field of road safety, in terms of the health of the driver. There were also presented several methods of monitoring the most important vital signs as well as the normal health values should fit in.*

Key words: *health-monitoring, driver, safety in automotive, vital signs, sensors.*

1. Introduction

Road safety is a very important and well known problem. Due to the fact that the number of cars is in a continuous growth, the biggest battle concerns the decrease the number of car accidents and the creation of safer and safer cars. This area is so important that many governmental bodies from the developed countries have issued a number of requirements for road safety related systems. For the past decades, a large number of projects or studies have been carried out under the flag of road safety, intelligent transportation, IVIS (in - vehicle information system) and DSS (driver support systems). There are hundreds of active projects in industry, universities and research centres [3].

A driver develops the skills necessary to control the vehicle through training. These skills involve: starting and accelerating the vehicle to the desired speed; braking to slow or stop it; directing vehicle for the proposed trajectory, safe overtaking, parking or reversing.

The driver interacts with both the car and the environment (implicitly the other drivers as well). As they learn to drive, they form a certain skill for better control of the vehicle. This skill (ability) is different from a driver to another.

Hence, the driver assistance system refers to a system that is designed to help the driver when he is in a situation that could endanger the life of other road users or passengers in the vehicle, or even the vehicle integrity [4].

After a review of the existing work in the field, a new system will be presented by means of which the vital parameters of the driver will be monitored.

2. Related Work

The Advanced Driver Assistance Systems (ADAS) support the decision to increase driver safety and comfort, providing leading environmental monitoring and issuing warning signals or even exerting an active control in case of dangerous conditions [7].

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For the ECG signal acquisition, Schneider et al. [10] embedded capacitive electrodes in the driver's seat. The electrodes had to be attached without disturbing the position of the seat and at the same time, they should be adjustable. In addition, the relevant safety components such as airbags must remain functional.

Research on wearable monitoring systems was the focus in recent years. It is believed that intelligent embedded systems are one of the possible options to control future health care costs in the society. The demographic changes which many countries are facing will be accompanied by a growing number of older drivers, and thus medical support in vehicles is expected in order to keep attracting the attention of the healthcare provider or emergency services.

Portable health monitoring systems may include various types of sensors in miniature, wearable or even implantable. These biosensors are able to measure significant physiological parameters such as heart rate, blood pressure, body and skin temperature, oxygen saturation, breathing rate, ECG etc. [9].

To monitor vital signs such as electrical and mechanical activity of the heart and breathing rate, Leonhardt et al. [8] investigated and subsequently implemented three non-contact methods of monitoring, i.e. capacitive ECG monitoring (CECG) monitoring the heart activity using the ballistocardiograms (BCG), and monitoring the heartbeat and breathing activity by magnetic impedance.

Silva el al. [11] proposes a system that allows the identification of the driver, using the information extracted from the electrocardiographic signals (ECG) collected from both hands. This approach uses a custom device detection, which allows the acquisition of data through non-intrusive techniques, while being easily integrated into the vehicle. The hardware was designed specifically to be mounted on the steering wheel, or to be integrated into other components with which the driver interacts naturally. Comparisons have been made between different representations of ECG (focusing on real-time applications), along with a simple classification method to determine the identity of the driver.

This system is also prone to enhance the safety characteristics, since it is based on a vital sign. Considering the acquisition method, it can provide insight about different aspects, such as hands off the wheel. In addition, if combined with ECG analysis algorithms it may also be used to detect medical events.

Besides that, this system also includes a processor for receiving the information about the physical condition of the driver from the listed sensors and also the detection of natural salt and the stress level of the driver based on the information received. Depending on this information, the system can generate audible and visual alerts, or can initiate a phone call to a remote support centre.

3. Driver’s Healthcare Limits and Behaviour

Vital signs are measurements of the body's basic functions. The most important vital signs usually monitored by medical professionals and healthcare providers are: body temperature, pulse, respiration (breathing rate), blood pressure (blood pressure is not considered a vital sign, but is often measured along with other vital signs). Vital signs are useful in detecting or monitoring medical problems [1].

Body temperature is the most important indicator of health. Body temperature measured body's ability to generate and remove heat. The human body keeps the body temperature within certain limits, declared normal, and is not influenced by the temperature of the environment.

Normal body temperature is 37 degrees Celsius. This temperature can vary with half a degree more or less. Also, the body temperature varies during the day, depending on various factors such as time of day, the ambient temperature or the age of the person.

If the body temperature drops one degree, and reaches 36 degrees, the reaction time and thinking capacity are seriously affected. If it reaches only 35 degrees, that person is no longer able to keep the vehicle's steering wheel and braking and stopping manoeuvres off the road become extremely difficult to do. At 33 degrees, the man becomes completely irrational, and at a temperature of 32 degrees, most people collapse and every human being becomes unconscious once its body temperature reaches 30 degrees. At 20 degrees, the heart stops beating.

Conversely, if the temperature increases by one degree, reaching approximately 38 degrees Celsius, symptoms of fever are installing. When the thermometer shows more than 39 degrees Celsius, the fever becomes harmful, usually signalling a potentially dangerous infection. If the temperature is above 40 degrees Celsius, urgent intervention of a specialist is needed. The temperature of 42 degrees Celsius has a high degree of risk, as it is at the maximum limit compatible with human life.

The respiratory rate represents the number of respirations of a person in a minute. This is usually measured when the person is at rest, by simply counting the number of breaths for one minute, by counting the frequency of lifting the thorax (chest). The respiratory rate may increase with fever, various diseases or other medical conditions. When the breath is verified, it is important to note, also, if the person has any breathing difficulties. A normal respiratory rate for an adult is in the range of 15 to 20 breaths per minute. The respiratory rate over 25 breaths per minute or less than 12 breaths per minute may be considered abnormal [1].

The normal pace, physiological, (relatively) regular heart rate of a healthy person is called "sinus rhythm". It is classically defined by regular rhythmic cardiac activity, with frequency between 60-100 beats per minute; it seems however that these frequency limits are not exactly correctly chosen: on the one hand, there are plenty of healthy individuals whose heart rate is 50-60 beats per minute, and on the other hand, it was found that standing heart rates between 85-100 beats per minute are neither signs nor prerequisites for a full cardiac health. Therefore, according to the latest research, normal heart rate should rather be defined between 50-85 beats per minute. Things are not so simple neither concerning the regularity of the sinus heart rate: in a superficial approach, heartbeat seems to be regular, but monitoring closely the (apparently) rhythmic activity of the heart, a significant and almost permanent variability was observed. Thus, the heart rate may be modulated according to the physiological needs of the body, but also according to any pathological conditions.

4. Identifying the State of Health

The temperature can be measured using special devices in different places of the body, the most common being the mouth, ears, the axial (armpit) and in special cases, even in the forehead.

The respiratory rate is a vital sign used to monitor the disease progression and an abnormal respiratory rate is an important marker of serious diseases. There is substantial evidence that changes in the respiratory rate can be used to predict serious clinical events such as heart failure. A complete breath consists of two distinct phases: inspiration, i.e. taking air (gas) from the environment in the body, and exhalation, which removes the air outside the body used (spent). By breathing oxygen (O_2) in the inspired air, it reaches the cells, and carbon dioxide (CO_2) output is released through the nose or mouth, through exhalation.

The respiratory rate monitoring devices are grouped as follows: monitoring via contact or contactless. In the contact respiration rate monitoring, the tool makes direct contact with the subject's body. However, in the non-contact monitoring, the breathing rate is measured without any contact of the instrument with the body of the subject.

Monitoring the respiratory rate by means of contact instruments are usually based on the measurement of one of the following parameters: respiratory sounds, airflow, respiratory movements of the chest or abdominal movements related to the respiratory system, respiratory CO_2 emissions or SpO_2 oximetry. The rate of respiration can also be derived from the electrocardiogram (ECG).

For noncontact respiratory monitoring methods, Greneker [5] has proposed a system called Radar Vital Signs Monitor (RVSM). This system detects breathing-induced movements of the chest using the Doppler phenomenon. Others noncontact methods are optical based respiration rate monitoring and thermal sensor and thermal imaging based [2].

The blood pressure is an important physiological feature of the cardiovascular system. The sequence of rhythmic contraction and relaxation of heart muscle develops an oscillatory flow of blood through the body. The blood pressure is measured both at the time of contraction of the heart and the relaxation time.

In general, the blood pressure is the pressure exerted by the blood on the blood vessel wall. Thus, it can lead to high blood pressure, venous, intra-pulmonary, intra-ocular etc. Of the pressures above mentioned, the most often measured is the arterial pressure, the pressure in large arteries respectively. The pressure of blood in other blood vessels is less than the arterial pressure.

The ECG is recording the cyclic variations of the electric field induced by cardiac activity. The heart can be considered a battery, a power generator included in a volume conductor (the body). The heart generates an electric field can be shown on the body surface by electrodes placed on the skin.

5. The Proposed System for Monitoring Driver's Health

Based on the theoretical and experimental achievements presented, the system from Figure 1 was proposed for being developed. This system will have as main objective the monitoring of the health of the driver, through a complex system of sensors that will be placed inside the car (on the steering wheel, on the seat belt, gear, chairs, mirror). Also, sensors must be mounted on the vehicle; they will monitor the browsing environment to ensure safe stopping of the car.

The signals will be collected in real time from the sensors monitoring both the health of the driver and the environment for sensing the navigation. Each vital sign will be monitored by at least two sensors. Therefore the data will be compared in order to increase the accuracy of the system. After that, the processed data will be sent to the embedded control unit via a protocol of communication and control signals.

The driver's vital signs that need to be monitored are: respiration rate, blood pressure, heart rate and body temperature, Figure 2. Thus, for each vital sign monitored a database of vital health limits will compile to know exactly at what stage is the driver.

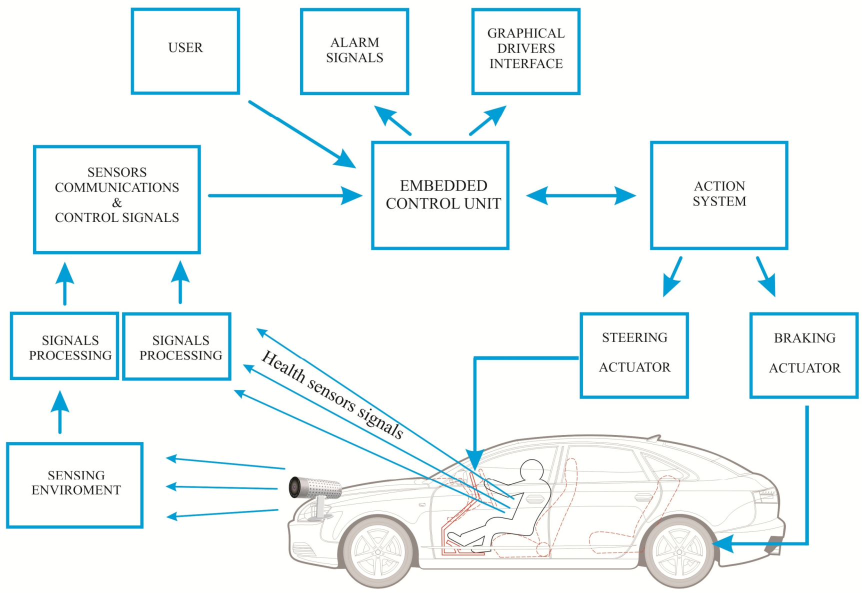

Fig. 1. *System architecture*

After setting the values of vital limits, the central unit of processing will make decisions based on the health of the driver. The driver will be able to watch on the graphical interface of the system the parameters monitored and will receive warning messages (both audible and visual (shown on the display)) if he starts to feel bad. If the driver is evaluated as unable to driving, the system will intervene. This approach consists in stopping the vehicle safely off the road in all weather conditions and calling a rapid response medical service for communicating the position.

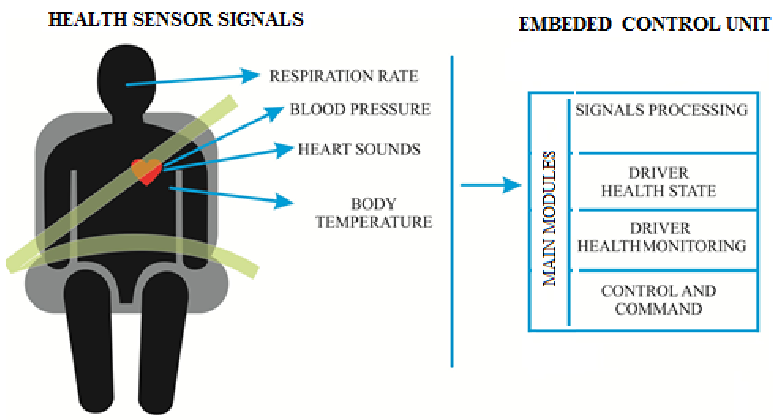

Fig. 2. *Vital signs proposed to be measured and processed*

6. Conclusion

This paper presents the current state of research in the field of road safety. Issues related to driver safety in medical terms were discussed, especially if he is able to drive the vehicle. Also, systems implemented for the safety of other road users (other drivers, passengers in vehicles or pedestrians) and the related vehicle integrity (environment) were reviewed.

Methods for monitoring the vital signs of the driver: body temperature, pulse, respiration (breathing rate) and blood pressure. Thus, normal values were found for the most important vital signs, as well as cases where the limits of these values are exceeded.

The most important function that is intended to be implemented is to create a robust system that will be able to monitor in real time the health of the driver. Thus, when the driver is no longer able to control the car, the system should operate in such a way that will be able to avoid a possible accident.

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