

In-car health and wellness monitoring

A Tata Elxsi Perspective



Abstract

In-car wellness and health monitoring of the driver are not something that one would have heard about earlier. But as we spend more time in our cars, grow more conscious and involved with monitoring their own health, cars may become a very natural place to monitor key health and wellness indicators. Many automobile manufacturers are dedicating time to understand and appreciate the value of being able to connect to health and wellness-related services while driving.

During the Digital Health Summit at the 2012 International Consumer Electronics Show (CES), Ford, Microsoft, Healthrageous and BlueMetal Architects announced an alliance to research on technology to help people monitor and maintain health and wellness while on the move. This initiative has attracted attention and many automobile manufacturers are exploring new avenues related to health and wellness.

Monitoring the vital parameter with negligible or minimum cooperation from the driver is a challenge. In addition to this, another exponent has added to the design complexity which must ensure minimum false alarms, quick decisions with the help of intelligent and powerful algorithms. This system also demands new generation sensors, complex digital image processing and an ecosystem comprising biologists, cognitive psychologists, Mechatronics engineers, automobile engineers, psychologists, human factors and usability experts.

The automobile industry has undergone a revolution in the recent past and cars are practically higher end microprocessors on wheels and so on In-car health and wellness monitoring will become the key differentiator. It is important not to be left behind in this race to offer the customer the best “medical device” car.

There are bound to be regulatory bottlenecks as one is approaching the regulatory boundaries. The thin line of device classification has to be appreciated and followed with due diligence. This domain is a goldmine of opportunities as the health conscious modern man is not leaving any stone unturned, as far as health and wellness are concerned.

Introduction

With chronic illnesses rising, people of all ages and from all income groups are taking a more hands-on approach to health and wellness. More people now visit online health sites than go to the physician's office, making health and wellness the most popular activity on the web after email and general searches.

According to a study conducted by Pew Research:

- 93 percent said they seek out online health information because it's convenient – they want to get information on their own timetable, not the physician's
- 83 percent said it's because they can get more information from the Web than they can get from their own physician
- 80 percent said getting this information privately is important to them

Moreover, beginning last year, medical and healthcare was the third-fastest-growing category of smartphone apps, with more than 17,000 available for download. And by 2015, some 500 million people are expected to be using mobile healthcare apps. The convergence of technology and the technological innovations in mobile technology have not only shrunk the world, but also helped people to monitor their health and connect to the healthcare provider.

Here we introduce the concept of using the motor vehicle as a device to collect and deliver physiological information, which, in turn, may enable people to drive safely by reducing the chances of medical mishaps behind the wheel. The development of in-vehicle health and wellness monitoring presents a new opportunity for novel collaborations between automobile and medical device industries, which have safety as a common core value.

In the United Kingdom, the time spent traveling by car averages 383 hours per person per year, or around 38 minutes a day. In the United States, the nationwide average drive time approximates to 24 minutes per day.

The demographic changes that many countries are going to face will be accompanied by an increasing number of elderly car drivers, and thus automotive health and wellness support is expected to attract further attention by insurances, health care providers or emergency services. For example, driver fitness monitoring is of major concern, when acute health problems impair the ability to drive safely. A car-integrated medical sensor system could be capable of detecting such critical conditions and initiate appropriate measures ranging from drive interventions (e.g. safety auto pilot) to emergency services (e.g. Car to car or car to emergency communication services, qualified ambulance call). If the sensor system inside the car is able to acquire validated physiological data on a regular basis, the vital signs data can also be used in a broader context as part of a general health and wellness monitoring system, extending the range of coverage and connectivity.

Why, what and how to monitor the driver

Why to monitor the driver

Health technologies inside a car can contribute to safety enhancements as well as health and wellness aspects by monitoring vital signs. Accidents are many times caused by tiredness, distraction, or bad state-of-mind drivers. The managing of human factors needs control, recording and monitoring of the most important vital parameters of the driver. We now know why to monitor the driver, but what to monitor and how to monitor the driver is a not only a major technical challenge, but also a reflection of the paradigm shift in the way healthcare is moving forward.

What to monitor?

Monitoring people with chronic illnesses while on the move was always a major concern, but there is light at the end of the tunnel thanks to better connectivity solutions that offer better quality of life to people. The motor car is an inevitable feature of our lives, considering the amount of time spent in the car /behind the wheel. By monitoring the health of the driver or a passenger while in the car by collecting physiological and clinical information may

enable more people to drive more safely by reducing the chances of medical mishaps behind the wheel. This is particularly relevant for people living with chronic illness who are at risk from a number of medical conditions that have the potential to have an impact on safe driving. The development of in-vehicle medical monitoring enhances not only quality of life, but also bring peace of mind to the family members. A car-integrated medical sensor system could be capable of detecting such critical conditions and initiate appropriate measures ranging from drive interventions (e.g. safety auto pilot) to emergency services (e.g. car to car or car to emergency communication services, qualified ambulance call). If the sensor system inside the car is able to acquire validated physiological data on a regular basis, the vital signs data can also be used in a broader context as part of a general home-health monitoring system, extending the range of coverage and connectivity.

Vital parameter monitoring of the driver will provide not only his health condition, but also a fair assessment of the known medical condition. But detecting any variation in the vital signs or the known medical condition (BP, diabetes) will help in taking the right corrective action, such as taking the medication, informing the care provider, alerting the family member or stopping the car (automatically or with intervention).

How to monitor

Monitoring of the vital parameters may be done intrusively or non-intrusively. It is of great importance to note that in-car health monitoring may be mostly opt-in solutions than mandatory. At no point of time, comfort of the driver should be compromised and that would make non intrusive monitoring a better option for in-car health monitoring.

In-car health monitoring concepts

ECG monitoring with sensors embedded in the steering wheel-non intrusive

ECG may be monitored using sensors embedded in the steering wheel as shown below. But the fact that many people use only one hand to drive makes this less feasible. The possible changing of lead configuration while countering a curve may also make it difficult to acquire ECG as steering rotation may be more.

ECG monitoring with sensors embedded in the seat back - non obtrusive

An ECG can be monitored in an unnoticeable manner using sensors embedded in the seat back.

Using IR sensors it is possible to measure body temperature in a non-contact manner. Based on the temperature measured dehydration level may be estimated based on the distance traversed, energy spent while behind the wheel.

Sensors for ECG monitoring - non obtrusive

The emergence of new generation sensors has made the task of bio-signal acquisition easy. Conductive fabric, capacitive electrodes are used to acquire ECG from the driver. Aachen University has done excellent research in using capacitive electrodes (Fig 5a). There are numerous research teams working in this domain and some findings are very interesting.

With the results achieved in this joint project between the Philips Chair of Medical Information Technology at RWTH Aachen University and the European Ford Research Center, an important milestone in the field of vital monitoring during car driving has been reached. It is shown that a clinically usable ECG can be recorded in a contactless way, without any restriction of comfort. Policy Semiconductors' award winning EPIC™ sensor technology has created considerable interest with car manufacturers as it can be used to provide low cost, reliable detection systems for several automotive applications. Plessey is now producing a version that is ideal for certain types of contactless ECG measurement.

Respiration monitoring

Respiration rate, which is an important vital sign may also be monitored either using EPIC sensors or using accelerometers.

Integrated BP monitor

BP can be effectively monitored by integrating a small form factor BP monitor on the “health cockpit” of the car. It is also possible to use BP monitors, which are available in the wristwatch form factor.

Integrating Blood glucose monitor

Blood glucose monitor (COTS) can be integrated with the infotainment system. Based on the glucose level detected corrective action may be carried out

Allergy/Asthma monitor and alerts

Based on the location based alert on pollen levels, pollution levels, the allergy alert system can be implemented.

Regulatory Approval

The trend of monitoring the vital signs of the drivers is catching up with car makers. But this can run into potential regulatory obstacles as medical device needs to be modified for in car usage to the point that it would need to get it re-approved by the FDA

Wellness monitoring - Overview

In-car wellness monitoring is classified as safety related, opt-in solutions and solutions that enhance driving experience. The prime goal is to ensure safety of the driver and fellow passengers it is important that safety built in as a derivative conscious engineering decisions based on many factors.

Safety related wellness monitoring

In the Safety related wellness monitoring, psychophysical monitoring, fatigue assessment and other human factor related monitoring may be done to ensure paramount safety to the driver.

Drowsiness detection

An infrared camera is installed, which maps the human face to detect whether the driver is drowsing off to sleep or watching away from the road. In conjunction with this system, this technology will enable the car to deploy safety airbags quicker in case it detects an imminent collision. It could also be made to apply brakes or alert the driver through speakers or vibration.

Road rage detection

European car safety researchers have developed a camera-based system that watches facial expressions of the driver while driving, and then uses highly accurate emotion detection algorithms to work out when the driver is “suffering” from road rage. The idea behind this system is that, when you’re irritated or angry, you become a more aggressive driver and less attentive — leading to more accidents. The same technology can also be used to measure tiredness and fatigue, by measuring the percentage of your eyelid closure, and then warning you to take a break before you fall asleep at the wheel. This work, developed by EPFL’s Signal Processing 5 Laboratory (LTS5) in association with PSA Peugeot Citroen, uses an infrared camera placed behind the car’s steering wheel to track the seven universal hard-coded emotions that your face can show. If your face registers “anger” or “disgust” for long enough, the software decides that you are stressed out and probably about to do something stupid. Because this is a prototype, all the EPFL system does is to tell you when you’re suffering from road rage — but presumably a production version of the technology would do a lot more.

Fatigue detection

A system with an algorithm to estimate the fatigue level based on

- Total distance traversed
- Drowsiness estimation
- Energy spent while driving, can create an alarm to warn the driver that he must take a break

Opt-in solutions

Some features like passive alcohol monitoring, blocking cell phone (in flight mode through NFC tags) while driving may be offered as opt-in solutions whose usage is totally under driver's discretion.

Enhancing driving experience

Solutions based on augmented reality, gesture recognition and Haptics can enhance the driving experience and reduce driver distraction to such a great extent that safety while driving is really enhanced.

Gesture recognition

Gesture recognition, reduces driver distraction and enhances safety.

Opening Car Doors and Tailgates

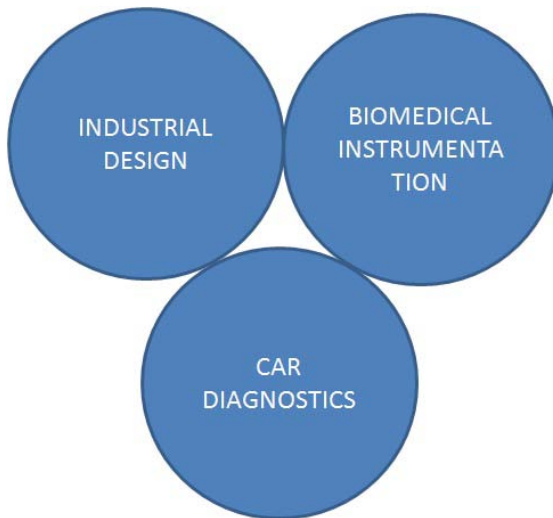
Opening doors and tailgates can be achieved by waving the ankles below the respective doors. It makes it very easy to open the doors when your hands are occupied carrying a heavy bag or a basket. Another usage of this system involves the opening and closing of sunroof by just reaching a hand towards it.

Controlling In-Car Infotainment Systems

Approaching your hand a few inches towards the infotainment system will activate its screen and present you with a bunch of relevant icons. As the technology concerning gesture-based and speech-based control systems improves, more features could be added to the car. Not only could hand and leg movements be detected, but a slight head movement could also be mapped to perform a certain function.

Tata Elxsi solutions for In-car wellness monitoring

Tata Elxsi’s proven expertise in biomedical instrumentation ably supported by industrial design and car diagnostics can offer excellent solutions for the challenges posed by the in-car wellness/ health monitoring applications.



In-car health and wellness monitoring will redefine the way cars will be designed in the way. It is important to be ahead in this so as not to be left behind in this race to design the FDA approved “medical device car”.

Conclusion

In the United States, the nationwide average drive time approximates to 24 minutes, with Americans spending more than 100 hours a year commuting to work. In the United Kingdom, the time spent traveling by car averages 383 hours per person per year, or around 38 minutes a day. The demographic changes that many countries are going to face will be accompanied by an increasing number of elderly car drivers, and thus automotive medical support is expected to attract further attention by insurances, health care providers or emergency services. A car-integrated medical sensor system could be capable of detecting such critical conditions and initiate appropriate measures ranging from drive interventions (e.g. safety auto pilot) to emergency services (e.g. car to car or car to emergency communication services, qualified ambulance call). If the sensor system inside the car is able to acquire validated physiological data on a regular basis, the vital signs data can also be used in a broader context as part of a general home-health monitoring system, extending the range of coverage and connectivity.

About the Author

Tata Elxsi's Medical Devices Practice has a multi functional leadership team with a combined domain experience of more than 200 person years. Tata Elxsi's solution team Works with the Medical Devices OEMs to solve the challenges and pain points in the dynamic medical device domain.

With proven expertise in monitoring, therapeutic and diagnostic medical devices backed up with a thorough understanding of the geography/country specific regulatory requirements, Tata Elxsi's solutions team encompasses interdisciplinary skills, which plays a pivotal role in conceptualizing and developing service offerings for the medical device domain.

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About Tata Elxsi's medical devices engineering services offerings

Tata Elxsi provides design and engineering services to the medical device industry. We understand the changing trends in this industry and offer services such as concept generation & validation, product development, verification & validation, and sustenance engineering.

With a unique focus on product design and engineering services, we provide services across the product development lifecycle. We have leveraged our cross functional domain expertise in the areas of connectivity technologies (Bluetooth, Wi-Fi, wireless), mobility solutions, and industrial design to provide cutting edge solutions to our clients spanning Diagnostic & imaging, ventilator, infusion pump, therapeutic, surgical equipments, point of care, endoscopy, diabetes devices and tele-health solutions.

About Tata Elxsi

Tata Elxsi is a design company that blends technology, creativity and engineering to help customers transform ideas into world-class products and solutions.

A part of the \$100 billion Tata group, Tata Elxsi addresses the communications, consumer products, defence, health care, media & entertainment, semiconductor and transportation sectors. This is supported by a network of design studios, development centers and offices worldwide. Key services include embedded product design, industrial design, animation & visual effects and systems integration. Tata Elxsi is a listed company and headquartered in Bangalore, India.

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