Medical technology in smart cars

Project work of group 5

Spring Semester 2015

IMT 3591 Artificial Intelligence
Gjøvik University College

Laodice Melliti
Matr.-Nr: 140159
laodice.melliti@hig.no

Jonas Helbig
Matr.-Nr: 140165
jonas.helbig@hig.no

March 7, 2015

Abstract

This document is part of our project for the course Artificial Intelligence at Gjøvik University College. This paper describes the architecture and framework of a system which helps elderly and/or people with chronic illnesses, with detection and prevention of potential harmful incidents while driving a car.

Contents

1 Formal: Assignment 1

Group number: 5
Names of the group members: Laodice Melliti, Jonas Helbig
Contribution of Laodice Melliti: System 3, Our system, system architecture - graphic
Contribution of Jonas Helbig: System 1, system 2, Our system

2 Introduction

Throughout this paper, we will design an AI system, which could later be implemented in a smart car application. The primary goal of the system is to assist elderly or sick people during everyday driving situations.

We begin this paper with a look at the state of art in the area of in-car vital parameter monitoring. We give a short overview and look at three systems in more detail. Afterwards, we introduce and describe our proposed system.

3 State of the art

Apart from systems designed to prevent drunk driving or systems with eye recognition that detect if the driver falls asleep, there are surprisingly few public used or commercially available systems in the area of in-car vital parameter monitoring. Therefore, we focus here on research done in this area. In [4], the authors research on the validation of electrocardiography (ECG) measurement in a car-integrated test framework.

In [5] the authors describe the relevance of the heart rate variability (HRV), extracted from the ECG, for driver workload detection in real world driving.

In [6] the authors describe the development and testing of a smart cart seat to measure vital signs with non-contact methods.

In the next three sub sections we describe the work in [1], [2] and [3] in more detail.

3.1 System 1

In the paper [1] the authors describe the effects of long monotonous driving in a simulated session. Their architecture consists of several sensors that measure different vital parameters like skin temperature, peripheral resistance and normalized pulse volume. As actuators, they use a display for real-time monitoring and they save the data for offline-analysis. The system itself only measures and presents the data, without taking further actions based on it.

3.2 System 2

In the paper [2], the authors use a system of sensors to find correlations between vital parameters like galvanic skin resistance, peripheral temperature and heart rate variability to determine the psychophysical state of the driver. This is especially for sleep attacks and micro-sleeps detections. The architecture consists of several sensors for vital parameter measurement. The actuators consist of a display and several computers to see the data in real-time and to save the data for later analysis. Their long-term goal is to develop a learning agent system which adjusts itself over time to the person usually monitored.

3.3 System 3

In the paper [3], the system calculates the driver‘s stress level by measuring his vital signs. The sensors are integrated in the car, mainly in the steering wheel. The car displays the results at the driver‘s demand and, depending on the results, can adjust the music‘s volume and/or block incoming phone call.

4 Our proposed System

Our system, the smart car, is to assist sick and/or elderly people when they need to drive by regularly checking their health. To do so, we will implement sensors in the car to measure heart rate, blood pressure and skin resistance. By using the gathered data, the car calculates the stress level, the state of consciousness and the general health of the driver. With that, it can warn the driver to, depending on the situation, consider an appointment with a doctor or to call an ambulance. If the driver has too poor health, the car will first ask whether to call for an ambulance or not. If no answer is given, then it will call the ambulance anyway. If, once the call is made, the driver does not talk, the car will send the coordinate using the data from the GPS.

4.1 PEAS Description

Performance The car needs to be able to detect when the driver‘s state is harmful for himself and/or other (for example, if the blood pressure is too low there is a risk of losing consciousness) and to warn the driver of his condition.

Environment For this project, we only consider the driver, the car (which includes all the built in material) and two external devices (heart belt and pressure sensor) which will be further explained in the next paragraph. The environment outside of the car does not influence this system and we assume that the data is not invalidated by the driver‘s clothes.

Actuators We have three actuators. First, a mobile phone which is built in the system. It will call the ambulance if needed. Secondly, speakers that are built in too. We are using the radio speakers. If the driver is listening to it, then the car will overwrite it in case of an emergency. Thirdly, an interface (touch screen) placed next to the radio that can display what the car say.

Sensors We have three sensors for medical data and two other kinds of sensors. For the medical data, both the blood pressure and the heart beats will be sensed using an external device. We will use a blood pressure meter and a heart belt for the heart pressure. Those devices will be put directly against the driver‘s skin. As for the skin resistance, we will put the sensors on the stirring wheel. Supposing that the driver drives normally and without gloves, then we can read the data from the tip of the finger (which is the best). The last two sensors are a GPS, either built in the car or from a mobile phone, and the touch screen. The last one is used by the driver to interact with the car (for example when it asks to call for an ambulance).

4.2 System architecture

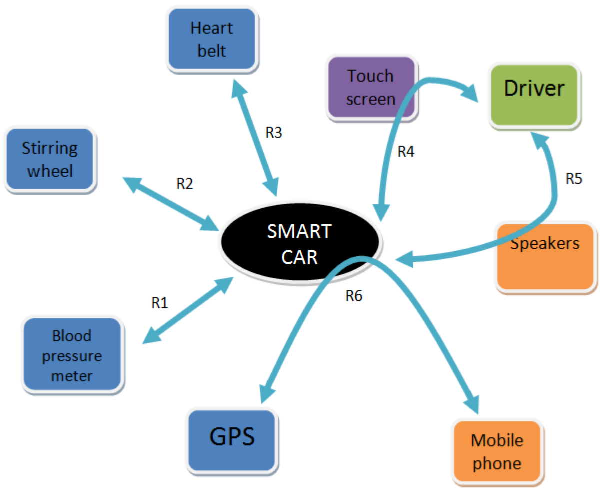

Figure 1: System Architecture

Our system architecture is presented in Figure 1.

R1: The blood pressure meter gets the blood pressures data (sensor).
R2: The stirring wheel gets the data about the skin resistance (sensor).
R3: The heart belt gets the data about the heart rate (sensor).
R4: The driver gives his answer using the touch screen (sensor & actuator).
R5: The smart car informs the driver of his state using the speakers (actuator).
R6: The smart car calls an ambulance using a mobile phone (actuator).
If needed, it uses the GPS coordinates (sensor).

Our system‘s main difference with the other existing project is that we reunite both the capacity to check the driver‘s health and the capacity to call someone (here, the ambulance). The combination of this two functionalities has yet to be reunited in the same smart car.

5 Formal: Assignment 2

Contribution of Laodice Melliti: Implementation scope, algorithmic design and description, implemented system architecture graphic
Contribution of Jonas Helbig: Implementation scope, algorithmic design and description

6 Implementation scope

The system as presented by us so far is too comprehensive to be fully implemented during this project. We this section we will give an estimation about which parts of the system can actually be implemented by us in the scope of this project.

Instead of focusing on emergency response systems with functions like detecting heart attacks, sleep attacks or even death during driving, we implement a system for long term measurement and monitoring of the user. We focus on three different health values, namely the heart beat, the breathing rate and the blood pressure. Our system is intended to be used by elderly people or people with illnesses affecting one of those parameters. We create a system capable of detecting unusual or undesirable development of a persons health over a longer period of 30-100 days.

In short, our system will create long term trends on the development of the user's health status. While doing that it is smart enough to detect unusal values and assess them in cooperation with the user to reduce or increase their influence on the trend. The process is further described in listing

1. For the initial setup of the training, we recommend the visit of a doctor. Since every patient has a different medical history, a doctor has to determine through several appropriate test the “normal” condition of the patient in reference to our desired parameters. After the initial setup, the system will be activated every time the users uses his car.

2. During each session the system will capture the parameters from the user, prepare and normalize the data and extract the features

3. The extracted features (as described later) will be processes by our system with the algorithms described in the next section

4. The system will react to unusual values, outside of the boundary predetermined by a doctor in the first step and it will try to find reasonable explanations in cooperation with the user, with a predefined question catalog. The questions can be answered binary, so that the user could easily give feedback without being distracted while driving

5. Depending on the responds of the user, the system will adjust its validation and weighting system for the calculation of the long term rating

6. Those ratings determined over a longer time will be repeatedly presented to the user, together with recommendations on how to react

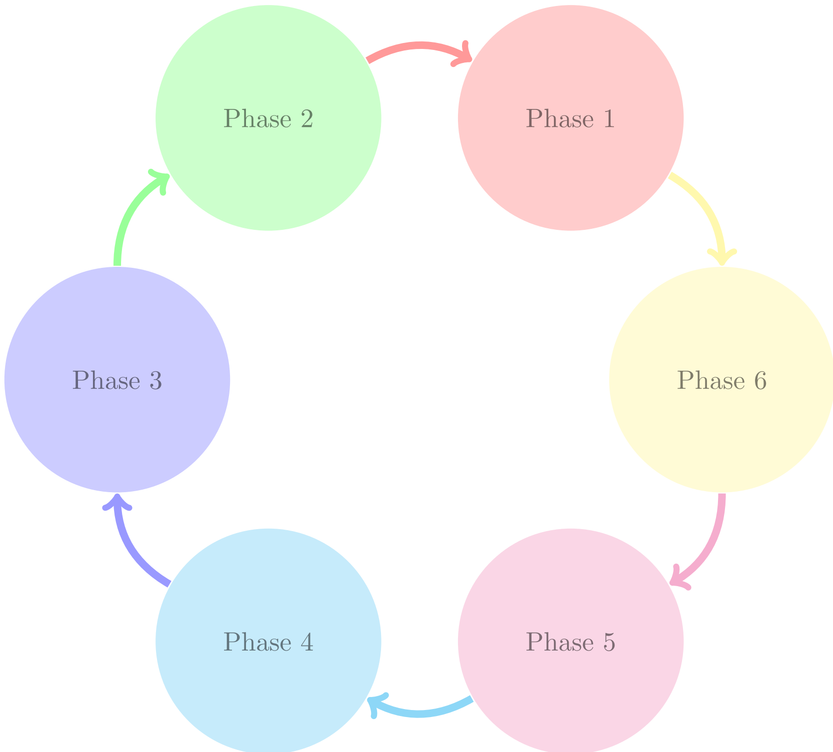

Figure 2: Process flow of our implementation

To reduce the complexity and avoid handling raw medical data, we are only implementing the steps three to six. The other steps would be scope of another research paper and should focus on the practicality of the extraction of the desired data. From the different sensors and actuators described in the last section we are going to use the following ones:

- Hear belt: From this sensor we use the heart beat rate and the breathing rate which is continuously measured. For our purpose, we assume that we get the values as heart beat per second.
- Blood pressure meter: From this sensor we use both the systolic and the diastolic blood pressure values. For our purpose, we assume that we get the values as millimeters of mercury
- GPS: For each dataset we save in the database we save the approximate GPS location

The process is summarized in figure **??**

7 Algorithmic approach

The pseudo code for our approach is specified through the algorithms 1 and 2. We focus on the important functions and aspects, without going into details about the capturing and preparation of the data. All the important functions and variables used are described below.

Algorithm 1 Capturing, processing and storing the data

Require: None
Ensure: Stores different important values in a database
  repeat
    $data \leftarrow CaptureData()$
    $data \leftarrow PrepareData(data)$
    $data \leftarrow ExtractFeatures()$ ▷ data: concrete numbers of BP/ BR and HB?
    $median \leftarrow Average(data)$ ▷ Average of the last 5 minutes
    $weight \leftarrow 1$
    $GPScoordinate \leftarrow GetGPS()$
    $weight \leftarrow 1$ ▷ Default value for the weighting function
    if OutsideBoundaries(median) **then**
      $response \leftarrow AskUserQuestions()$
      if then$response == yes$ ▷ //yes → valid reason for data out of boundaries
        $ReduceWeight()$
      else
        $IncreaseWeight()$
      end if
    end if
    $Store(median, weight, GPScooridinate)$ ▷ Save values in Database
  until Driving session is over
  $AverageOfSession()$ ▷ Presented at the end of each driving session

---

Algorithm 1

CaptureData() For the heart beat and breath rate: we capture the data every seconds. For the blood pressure, we capture the data every 30 minutes

PrepareData(data) We normalyse the data received and reduce the noise as much as possible.

ExtractFeatures() The data we previously captured is analog and we need digital data for the analysis. As such, we convert the analog data into digital data.

AverageData() Every 5 minutes, we make a average of all the data received.

OutsideBoundaries(data) We check if the data is outside the boundaries. Those boundaries are set up by a doctor when the system is implemented in the car. This function return a boolean variable
True: the data is outside the boundaries
False: the data is inside the boundaries. In this case we assume everything is fine

askUserQuestion() We ask the driver if he had exerciced recently and if he is feeling unwell or stressed. If the answer to any of this questions is yes, then

Algorithm 2 Long term monitoring

Require: Database
Ensure: Recommendation for the user
  repeat
    $data \leftarrow ReadDatabase()$
    $rating \leftarrow 0$
    for Every dataset in data **do** ▷ every dataset consists of median, weight and gps
      $rating \leftarrow rating + weight * median$
    end for
    $rating \leftarrow rating/data.lenght$ ▷ Average with weight
    if OutsideBoundaries(rating) **then**
      $makeRecommendation()$
    end if
  until 24 hours are over

the function return a boolean variable set to true. Otherwise, it returns false.

Store(median, weight, GPScooordinate) We store together all the medians, their weight and the GPS coordinates assiociated into the database.

AverageOfSession() We make an average of all the data received dureing the drivinig session so that we can compare two driving session one to the other.

Algorithm 2

ReadDatabase() We put a specific anount of data into a new variable to analyse this whithout accidently changing our saved data.

OutsideBoundaries() See function capture

makeRecommendation() Depending of the result, we either make recommendation to see a Doctor (via speakers) or we inform the driver that everything is fine.

8 Updated system architecture

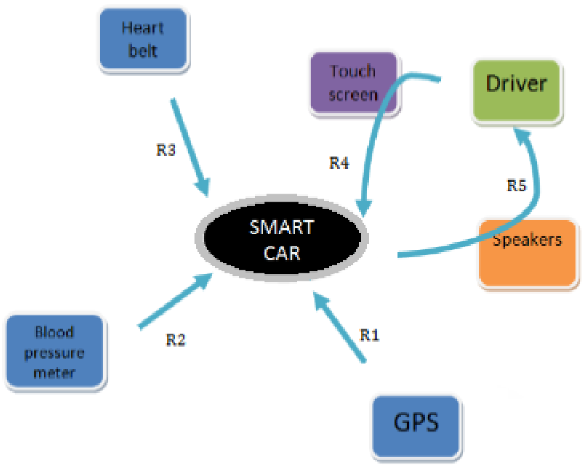

Figure 3: System Architecture redefined for the scope of our project

References

[1] T. Yamakoshi, K. Yamakoshi, S. Tanaka, M. Nogawa, M. Shibata, Y. Sawada, P. Rolfe, and Y. Hirose, "A preliminary study on driver's stress index using a new method based on differential skin temperature measurement," in *Engineering in Medicine and Biology Society, 2007. EMBS 2007. 29th Annual International Conference of the IEEE*, pp. 722–725, Aug 2007.

[2] C. Zocchi, A. Rovetta, and F. Fanfulla, "Physiological parameters variation during driving simulations," in *Advanced intelligent mechatronics, 2007 IEEE/ASME international conference on*, pp. 1–6, Sept 2007.

[3] L. D'Angelo, J. Parlow, W. Spiessl, S. Hoch, and T. Luth, "A system for unobtrusive in-car vital parameter acquisition and processing," in *Pervasive Computing Technologies for Healthcare (PervasiveHealth), 2010 4th International Conference on-NO PERMISSIONS*, pp. 1–7, March 2010.

[4] J. Schneider, C. Koellner, and S. Heuer, "An approach to automotive ecg measurement validation using a car-integrated test framework," in *Intelligent Vehicles Symposium (IV), 2012 IEEE*, pp. 950–955, June 2012.

[5] B. Eilebrecht, S. Wolter, J. Lem, H. Lindner, R. Vogt, M. Walter, and S. Leonhardt, "The relevance of hrv parameters for driver workload detection in real world driving," in *Computing in Cardiology (CinC), 2012*, pp. 409–412, Sept 2012.

[6] M. Walter, B. Eilebrecht, T. Wartzek, and S. Leonhardt, "The smart car seat: personalized monitoring of vital signs in automotive applications," *Personal and Ubiquitous Computing*, vol. 15, no. 7, pp. 707–715, 2011.