

# Mobile Sensing of Stress Detection and Vehicle Control for Bus Drivers

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**ABSTRACT:** Experience of daily stress among bus drivers has shown to affect physical and psychological health, and an impact driving behavior and overall road safety. Although previous research consistently supports these findings, little attention has been dedicated to the design of a stress detection method able to synchronize physiologic and psychological stress responses of public bus drivers in their day-to-day routine work. To overcome this limitation, we propose a mobile sensing approach to detect geo referenced stress responses and facilitate memory recall of the stressful situations. Data was collected among public bus drivers in the city of Porto, Portugal 145 hours, 36 bus drivers, and +2300 km and results supported the validation of our approach among this population and allowed us to determine specific stressor categories within certain areas of the city. Furthermore, data collected through-out the city allowed us to produce a citywide stress map || that can be used for spotting areas in need of local authority intervention. The enriching findings suggest that our system can be a promising tool to support applied occupational health interventions for public bus drivers and guide authorities interventions to improve these aspects in future cities.

## I. INTRODUCTION

### 1.1 Real-Time Driver's Stress Event Detection

In this paper, a real-time methodology for the detection of stress events while driving is presented. The detection is based on the use of physiological signals, i.e., electrocardiogram, electro dermal activity, and respiration, as well as past observations of driving behaviour. Features are calculated over windows of specific length and are introduced in a Bayesian network to detect driver's stress events. The accuracy of the stress event detection based only on physiological features, evaluated on a data set obtained in real driving conditions, resulted in an accuracy of 82%. Enhancement of the stress event detection model with the incorporation of driving event information has reduced false positives, yielding an increased accuracy of 96%.

### 1.2 An approach for real-time stress-trend detection using physiological signals in wearable computing systems for automotive drivers

Fast and credible identification and estimation of driver's stress-level and stress-type from sensed physiological signals has been one of the critical research areas in the recent past. Several good metrics and mechanisms involving bioelectric signals like the Galvanic Skin Response (GSR), Electrocardiogram (ECG) have been identified by the scholars over the years. This paper discusses the features extracted from physiological data collected in five different scenarios and their usefulness with the help of statistical trend analysis methods. The algorithm developed comprises of a novel shape-based feature weight allocation approach and a technique for credible online realtime stress-trend detection. Such a stress-trend detection by the mesh of embedded sensory elements residing in the e-fabric of a wearable computing system will help in reducing chances of fatal driving errors by the way of in-time activation of alerts and actuation of corresponding safety / recovery procedures.

### 1.3 Feasibility study on driver's stress detection from differential skin temperature measurement

Prolonged monotonous driving may lower a driver's awareness level as well as increasing their stress level due to the compulsion to maintain safe driving, which may result in an increased risk of a traffic accident. There is

therefore an opportunity for technological assessment of driver physiological status to be applied in-car, hopefully reducing the incidence of potentially dangerous situations. As part of our long-term aim to develop such a system, we describe here the investigation of differential skin temperature measurement as a possible marker of a driver's stress level. In this study, healthy male (n=18) & female (n=7) subjects were investigated under environment-controlled conditions, whilst being subjected to simulated monotonous travel at constant speed on a test-course. We acquired physiological variables, including facial skin temperature which consists of truncal and peripheral skin temperatures (Ts) using thermography, beat-by-beat blood pressure (BP), cardiac output (CO), total peripheral resistance (TPR), and normalized pulse volume (NPV) used as an indicator of local peripheral vascular tone. We then investigated the driver's reactivity in terms of skin temperatures with this background of cardiovascular hemodynamic. We found that the simulated monotonous driving produced a gradual drop in peripheral Ts following the driving **stress**, which, through interpretation of the TPR and NPV recordings, could be explained by peripheral sympathetic activation. On the other hand, the truncalTs was not influenced by the **stress**. These findings lead us to suggest that truncal-peripheral differential Ts could be used as a possible index indicative of the driver's stress.

#### **1.4 Medical signal processing by means of immune algorithms**

Medical signals are increasingly being used within healthcare for diagnosis, planning treatment, guiding treatment and monitoring disease evolution. Medical imaging mainly treats and processes missing, ambiguous, complementary, redundant, contradictory, distorted data, and information has a strong structural character. This paper reports two "immune algorithms" based approaches for medical signal processing. Immune algorithms belong to the Artificial Immune Systems field. The first proposed approach uses the Clonal Selection Algorithm (CSA) for geometric transform estimation in image registration (IR). The second approach, the Dendrite Cell Algorithm (DCA) is used for automatic driver stress detection using biomedical signals.

#### **1.5 Smart Car: detecting driver stress**

Smart physiological sensors embedded in an automobile afford a novel opportunity to capture naturally occurring episodes of driver stress. In a series of ten ninety minute drives on public roads and highways, ECG, EMG, respiration and skin conductance sensors were used to measure the autonomic nervous system activation. The signals were digitized in real time and stored on the Smart Car's Pentium class computer. Each drive followed a pre-specified route through fifteen different events, from which four stress level categories were created according to the results of the subjects self report questionnaires. In total, 545 one minute segments were classified. A linear discriminate function was used to rank each feature individually based on the recognition performance, and a sequential forward floating selection algorithm was used to find an optimal set of features for recognizing patterns of driverstress. Using multiple features improved performance significantly over the best single feature performance

#### **1.6 Enhancing in-vehicle safety via contact sensor for stress detection**

The number of vehicles on the road as well as the human drive time is increasing significantly. Many drivers are increasing their attempts to multi-task while driving including eating, drinking, entertainment control etc. A relatively new domain has emerged over the last 5 years focused on increased technology in the vehicle based on: GPS navigation systems, traffic, weather warning systems, advanced music/entertainment systems (e.g., MP3, iPod, etc), voice/cell-phone communications, email access and more recently text messaging. Such technology has significantly increased the cognitive stress load and/or distraction levels of drivers, yet little research has focused on this challenge. For communications alone, more than 60% of the cell-phone calls originated from the vehicle in 1997. The focus of the current study is to formulate and evaluate a cognitive stress detection scheme under a cell-phone-like scenario while driving. Also, the current study proposes use of a contact sensor for stress detection. We propose three proto-designs to incorporate contact sensors to enable both drivers safety and enhance overall in-vehicle safety. Another advantage of using a contact sensor is its ability to also capture drivers physiology (such as heart beat and breathing patterns).

### 1.7 Automobile driver's stress index provision system that utilizes electrocardiogram

This research intends to develop devices that make drivers rest and to verify in the early stage by effectively detecting the electrocardiogram (ECG) signal, one of the signals of living body, in the vehicle during the operation and providing ANS information and degree of stress. Recording the regular activity of heart clinically, ECG reflects the health state of subject as well as checks the degree of operation of autonomic nervous system through analysis of Heart Rate Variability (HRV). As this alteration of autonomic nervous system predicts the stress level of drivers during operation and provides the possibility of warning by continuous detection, it may lead to the recognition and safe driving of driver by detecting the stress during driving altered by diverse factors such as changing mood, bio rhythm, condition, fatigue, boredom or disease and preventing the driver from reaching the inappropriate state for driving. Thus, the reliability and utilization level of system was confirmed to be satisfactory by providing new ECG measuring method familiar to drivers and comparing it with the result of judging drivers' emotion through this research.

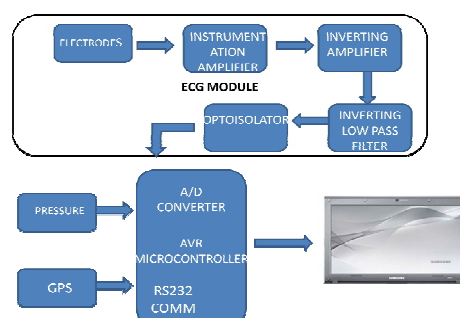
### 1.8 Analysis of Drivers' Responses under Hazardous Situations in Vehicle Traffic

This study focused on the analysis of drivers' reactions under hazardous scenarios in vehicle traffic. Driving behaviour signals were utilized to detect a chain of changes in driver status and to retrieve incidents from a large real-world driving database obtained from the centre for integrated acoustic information research (CIAIR). All the existing 25 potentially hazardous scenes in the database were hand-labelled and categorized. A new feature, based on joint-histograms of these behavioural signals and their dynamics was proposed and utilized to indicate anomalies in driving behaviour. Brake pedal force-based method attained a true positive (TP) rate of 100% for a false positive (FP) rate of 4.5%, concerning the detection of 17 scenes where drivers slammed on the brakes. Results stressed the relevance of individuality in drivers' reactions for this retrieval. In 11 of the 25 hand-labelled scenes, drivers reacted verbally. Scenes where high-energy words were present were adequately retrieved by the speech-based detection, which achieved a TP rate of 54% (6 scenes), for a FP rate of 6.4%. In addition, the proposed integration method, which combined brake force and speech signals, was satisfactory in boosting the detection of the most subjectively dangerous situations.

## II. PROPOSED METHOD

To sense the stress and memory activation for public bus drivers. Input of this project are Pressure. The current paper proposes an interdisciplinary method that combines physiologic, psychologic and geo referenced data to investigate sources of stress faced by bus drivers while driving in an ecological setting on a daily work basis. Our contribution includes the design of stress assessment software, adapted to the routine needs of bus drivers, and combines non-intrusive, user friendly and reliable physiologic and psychologic research methods, providing a continuous daily monitoring of the driver during the course of a day at work. The components used here in this project are ECG sensor, microcontroller, notebook pc, pressure sensor and GPS. ECG sensor is for recording the electrical activity of the heart over a period of time using [electrodes](#) placed on a human body. A pressure sensor usually acts as a [transducer](#); it generates a signal as a [function](#) of the pressure imposed.

### 2.1 BLOCK DIAGRAM



## **2.2 MICROCONTROLLER**

A microcontroller (sometimes abbreviated  $\mu\text{C}$ ,  $\text{uC}$  or  $\text{MCU}$ ) is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of Ferroelectric RAM, NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications

## **2.3 ECG SENSOR**

Recording the electrical activity of the heart over a period of time using electrodes placed on a human body. These electrodes detect the tiny electrical changes on the skin that arise from the heart muscle depolarizing during each heartbeat.

## **2.4 PRESSURE SENSOR**

A pressure sensor usually acts as a transducer; it generates a signal as a function of the pressure imposed.

## **2.5 GPS**

The Global Positioning System (GPS) is a space based navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.

## **2.6 NOTEBOOK PC**

A hardware specification for a handheld-sized smart phone or personal digital assistant (PDA), It has some of the abilities of modern desktop PCs

## **2.7 AVR STUDIO**

Atmel<sup>®</sup> Studio 6 is the integrated development platform (IDP) for developing and debugging Atmel ARM<sup>®</sup> Cortex<sup>®</sup>-M and Atmel AVR<sup>®</sup> microcontroller (MCU) based applications. The Atmel Studio 6 IDP gives you a seamless and easy-to-use environment to write, build and debug your applications written in C/C++ or assembly code. Atmel Studio 6 is free of charge and is integrated with the Atmel Software Framework (ASF)—a large library of free source code with 1,600 ARM and AVR project examples. ASF strengthens the IDP by providing, in the same environment, access to ready-to-use code that minimizes much of the low-level design required for projects. Use the IDP for our wide variety of AVR and ARM Cortex-M processor-based MCUs, including our broadened portfolio of Atmel SAM3 ARM Cortex-M3 and M4 Flash devices. The microcontroller is composed of an ARM7 processor core, a system controller, memory elements, and peripheral devices. It is noteworthy that the computational power of ARM7 is quite sufficient for the majority of embedded applications. For example, ARM7 can easily execute all benchmarks in MiBench benchmark suite. When you are looking for the right embedded processors, with the FutureElectronics.com parametric search, you can filter the results by various attributes: by Clock Frequency 16 Hz, 200 MHz, 266 MHz, 400 MHz, RAM size 512 B, 4 kB, 32kB, 64 k, Data Bus Width from 16 b to 32 b. ARM7 can also execute fairly complex operating systems e.g., Real-Time Executive for Multiprocessor Systems RTEMS and Keil RTX. Nevertheless, for highly computation-intensive applications, the performance of ARM7 might not be adequate. In this case, it should be noted that our proposed platform is not inherently dependent on ARM7. Most I/O lines of the peripherals are multiplexed with the parallel I/O (PIO) controller. Each PIO line may be assigned to a peripheral or used as general purpose I/O. These features provide flexibility to designers and assure effective use of the components.

## **A. COTS DEVICES ON EMBEDDED SYSTEM**

Commercial Off-The-Shelf (COTS) is a term that references non-developmental items (NDI) sold in the commercial marketplace and used or obtained through government contracts. The set of rules for COTS is defined by the Federal Acquisition Regulation (FAR). A COTS product is usually a computer hardware or software product tailored for specific uses and made available to the general public. Such products are designed to be readily available and user friendly. A typical example of a COTS product is Microsoft Office or antivirus

software. A COTS product is generally any product available off-the-shelf and not requiring custom development before installation.

### **B. ISOLATION AMPLIFIER**

Isolation amplifiers are a form of differential amplifier that allows measurement of small signals in the presence of a high common mode voltage by providing electrical isolation and an electrical safety barrier. Isolation amplifiers are a form of differential amplifier that allows measurement of small signals in the presence of a high common mode voltage by providing electrical isolation and an electrical safety barrier. They protect data acquisition components from common mode voltages, which are potential differences between instrument ground and signal ground. Instruments that are applied in the presence of a common mode voltage without an isolation barrier allow ground currents to circulate, leading in the best case to a noisy representation of the signal under investigation. In the worst case, assuming that the magnitude of common mode voltage or current is sufficient, instrument destruction is likely. Isolation amplifiers are used in medical instruments to ensure isolation of a patient from power supply leakage current.

### **C. RECORDING ELECTRODE**

Recording electrode transfers electrical potentials at the recording site to the input of the recording machine.

Device to record one of the two extremities of an electric circuit; one of the two poles of an electric battery or of the end of the conductors connected there. An electrical terminal specialized for a particular electrochemical reaction.

### **D. LOW PASS FILTER**

A low-pass filter is a filter that passes signals with a frequency lower than a certain cut off frequency and attenuates signals with frequencies higher than the cut off frequency. A low-pass filter is a filter that passes signals with a frequency lower than a certain cut off frequency and attenuates signals with frequencies higher than the cut off frequency. The amount of attenuation for each frequency depends on the filter design. The filter is sometimes called a high-cut filter, or treble cut filter in audio applications. A low-pass filter is the opposite of a high-pass filter. A band-pass filter is a combination of a low-pass and a high-pass filter.

Low-pass filters exist in many different forms, including electronic circuits, anti-aliasing filters for conditioning signals prior to analog-to-digital conversion, digital filters for smoothing sets of data, acoustic barriers, blurring of images, and so on. The moving average operation used in fields such as finance is a particular kind of low-pass filter, and can be analyzed with the same signal processing techniques as are used for other low-pass filters. Low-pass filters provide a smoother form of a signal, removing the short-term fluctuations, and leaving the longer-term trend. An optical filter can correctly be called a low-pass filter, but conventionally is called a long pass filter, to avoid confusion.

## **III. CONCLUSION**

The enriching findings suggest that our system can be a promising tool to support applied occupational health interventions for public bus drivers and guide authorities' interventions to improve these aspects in "future" cities. Stress caused by emotional upsets has been associated with several incidents among drivers. HRV can be calculated from the Electrocardiogram (ECG), and is reported to be an accurate measure of stress. Blood volume pressure monitored to measure the drivers stress level. The system was designed by an interdisciplinary team, in cooperation with bus drivers working in the city of Porto. The method validation was tested among a sample of bus drivers in their day-to-day routine. Results showed that the methodology is successful in detecting stressful events based on bus drivers' physiologic responses.



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