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COMPUTER SCIENCE MEETS AUTOMATION

VOLUME I

Session 1 - Systems Engineering and Intelligent Systems

Session 2 - Advances in Control Theory and Control Engineering

Session 3 - Optimisation and Management of Complex Systems and Networked Systems

Session 4 - Intelligent Vehicles and Mobile Systems

Session 5 - Robotics and Motion Systems

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Preface

Dear Participants,

Confronted with the ever-increasing complexity of technical processes and the growing demands on their efficiency, security and flexibility, the scientific world needs to establish new methods of engineering design and new methods of systems operation. The factors likely to affect the design of the smart systems of the future will doubtless include the following:

- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, beyond that in "classical" technical systems and processes, in environmental systems or medical and bioengineering applications.
- The boundaries between software and hardware design are being eroded. New design methods will include co-design of software and hardware and even of sensor and actuator components.
- Automation will not only replace human operators but will assist, support and supervise humans so that their work is safe and even more effective.
- Networked systems or swarms will be crucial, requiring improvement of the communication within them and study of how their behaviour can be made globally consistent.
- The issues of security and safety, not only during the operation of systems but also in the course of their design, will continue to increase in importance.

The title "Computer Science meets Automation", borne by the 52nd International Scientific Colloquium (IWK) at the Technische Universität Ilmenau, Germany, expresses the desire of scientists and engineers to rise to these challenges, cooperating closely on innovative methods in the two disciplines of computer science and automation.

The IWK has a long tradition going back as far as 1953. In the years before 1989, a major function of the colloquium was to bring together scientists from both sides of the Iron Curtain. Naturally, bonds were also deepened between the countries from the East. Today, the objective of the colloquium is still to bring researchers together. They come from the eastern and western member states of the European Union, and, indeed, from all over the world. All who wish to share their ideas on the points where "Computer Science meets Automation" are addressed by this colloquium at the Technische Universität Ilmenau.

All the University's Faculties have joined forces to ensure that nothing is left out. Control engineering, information science, cybernetics, communication technology and systems engineering – for all of these and their applications (ranging from biological systems to heavy engineering), the issues are being covered.

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.
I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.

Professor Peter Scharff
Rector, TU Ilmenau

Professor Christoph Ament
Head of Organisation

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52nd Internationales Wissenschaftliches Kolloquium
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10 – 13 September 2007

F. Müller / A. Wenzel / J. Wernstedt

A new strategy for on-line Monitoring and Competence Assignment to Driver and Vehicle

ABSTRACT

This paper presents a new strategy for driver monitoring and competence assignment based mainly on standard sensory equipment. Within this a competence adapter assigns a competence level to each of both subsystems, driver and vehicle. In this manner short- and long-term reduced capabilities of the driver in regard to his driving task can be detected and may even compensated under some circumstances. In this concept the driver still maintains his responsibility as long he is conscious.

1. INTRODUCTION

Driving cars does not only mean mobility for many people but also is connected with freedom and individuality by them. In the next decades many western societies will undergo dramatic changes due to the democraphic alteration. In addition to the fact, that driver of vehicles will get older in the mean, there will be the need for them to have access to individual mobility even in their later phase of life. That’s because of the turning away of traditional multi – generation households and increasing central supply facilities especially in urban areas. Driver assistance systems can help to safe the driving of older people. These often have face reduced capabilities notably in the perception of their environment and reaction time. Furthermore they are confronted with a higher risk for shock- or blackout syndroms resulting from specific diseases, like diabetes, represented more often at the group of elderly. The authors believe that the increasing possibilities of driver assistance systems are not only able to support and safe people in their late phase of life, but also can allow people with other limits in driving capabilities a form of individual mobility, which is safe for them and their environment in a most possible way. A integral part of this strategy is however the neccesity for the continous monitoring of the driver and vehicle as well as their competence assignment, which the rest of this paper deals with.

2. CYBERNETIC SYSTEM DRIVER – VEHCILE

Since the goal has to be that the vehicle and the driver do fulfill their driving task, the system driver – vehicle should be treated as one system and regarded as one. The cybernetic decision structure for the guidance of mobile systems/vehicles is based on the 3-level hierarchical structure illustrated in Figure 1, with level 1 as the autopilot layer for time-critical and safety-relevant control tasks as well as routine tasks, level 2 as the maneuver layer i.e. for track switching or overtaking and the Level 3 as mission layer for the planning, control and re-planning of a mission (route, course). The task distribution between the human and the vehicle within the levels is situation and task dependent and has changed drastically in the last decades.

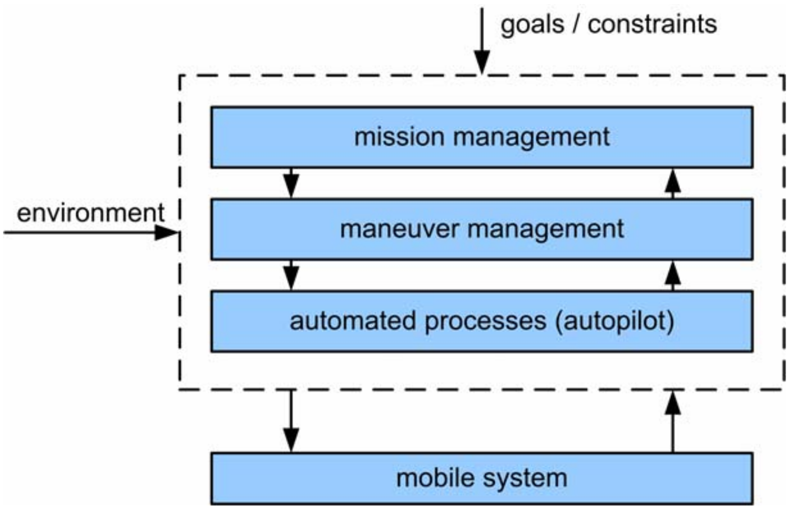

Figure 1: Decision structure for mobile systems

It is assumed that the development of automation and assistance systems will continue, but humans must and will further have the responsibility in the levels of mission and maneuver management.

3. SYSTEM CONCEPT

The concept of the proposed system is depicted in figure 2. The task of the competence adapter system (CAP) is to evaluate the monitoring signals from driver and vehicle, estimate the driver's condition as well as assist and safe the driver by appropriate measures. The system is based on the system description of the driver and the vehicle. Within this, the driver and the vehicle are modeled by their weighting functions $g_D(t)$ and $g_v(t)$ according to their laplacian transfer functions. The driver acts on the vehicle by the control vector $u_D(t)$, which consists mainly of accelerating,

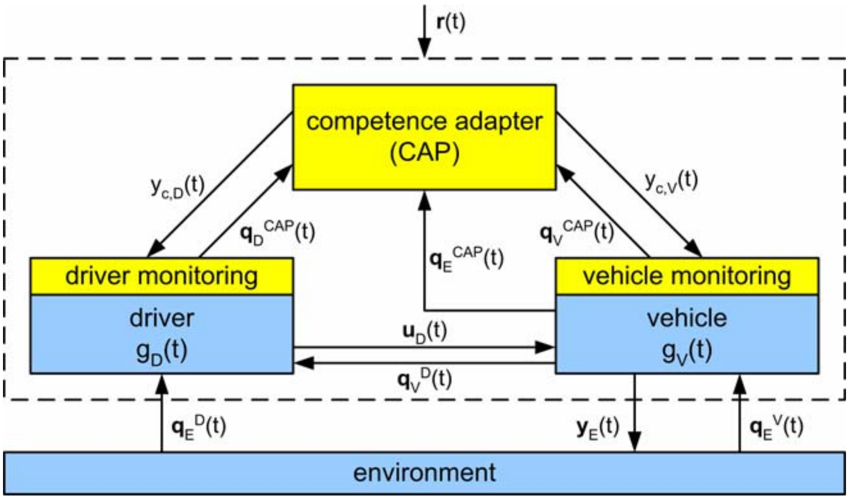

Figure 2: Overall system design

decelerating and steering the car, whereby the driver's inputs are the state vector of the environment $q_E{}^D(t)$ and the state vector of the vehicle $q_V{}^D(t)$ as seen by him. The changes in position and velocity as well as other output parameters of the vehicle with respect to itself and the environment are described by the vector $y_E(t)$. In addition to this basic structure, components of driver and vehicle monitoring as well as the competence adapter system are added to the system, which in result builds up the overall structure. In this regard vehicle monitoring is assumed to be relatively common in upcoming car generations and will provide a detailed survey about the vehicle's state [1]. The driver monitoring module and the CAP system are described more detailed in the subsequent parts of this paper. The vehicle monitoring system will then provide the state vector of the vehicle $q_V{}^{CAP}(t)$, while the driver monitoring system will provide the driver's state vector $q_D{}^{CAP}(t)$, both then as seen by the CAP system. In addition the vehicle sensory equipment generates the environment state vector $q_E{}^{CAP}(t)$ again as seen by the CAP system. The system's output are the parameters of competence assignment to driver and vehicle $y_{c,D}(t)$ and $y_{c,V}(t)$, as described later. The overall goal function is represented by $r(t)$. Note, that due to different perception the state vectors have to be distinguished according to the regarded system module. I.e. the state vectors of the environment as seen by the driver $q_E{}^D(t)$ and the CAP system $q_E{}^{CAP}(t)$ are different in general.

4. DRIVER MONITORING AND COMPETENCE ASSIGNMENT

Using the models for the driver, the vehicle [4] and the recording of substantial states of the environment (position, coordinates of the road, traffic conditions, etc.) the current condition of the driver $c_D(t)$ can be determined on the basis of a success-evaluated on-line action analysis using classification concepts [2]. It is suggested to make an on-line determination of a driver's condition $c_D(t)$ by sensor fusion according to the structure in figure 3. In this manner at present the behavior of the driver in regard to the distance

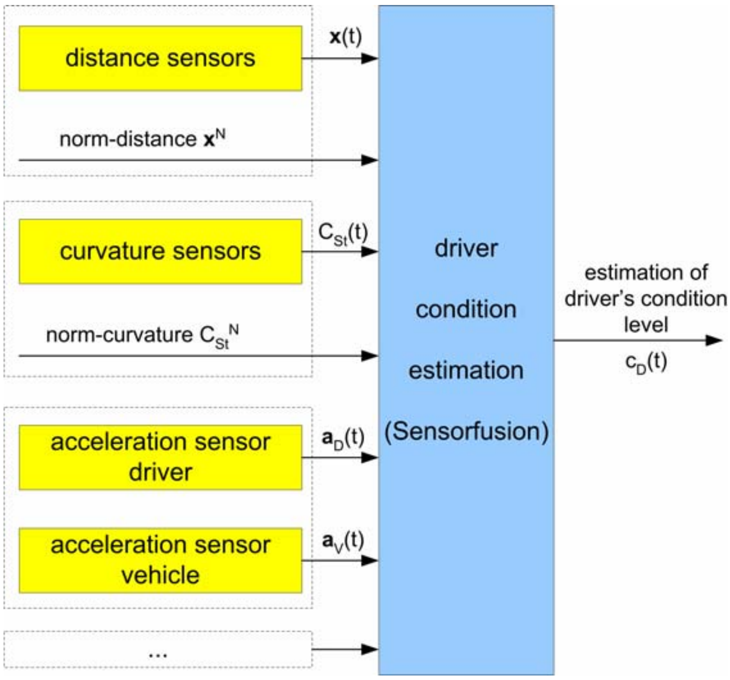

Figure 3: Determining of driver's capabilities with on-board sensors und measured physiological parameters with sensor fusion

to ahead driving vehicles and the driving of curved roads shall be examined. The novel concept addresses the expected standard equipments of vehicles in the coming years. Additionally selected physiological parameters of the driver are included in the monitoring. At first the norm distances x^N for e.g. the situations follow-up drivers, approaching, track switching, in-shearing and out-shearing have to be determined driver-specifically. These are compared situation-dependent with the actual recorded distances $x(t)$ of the driver. As a second input of the driver condition estimation module, the actual curvature driving behavior $C_{St}(t)$ is compared with the norm curvature ${C_{St}}^N$ derived from maps. A prospective physiological parameter is the model-based evaluation of the driver's acceleration $a_D(t)$ compared to the vehicle's acceleration $a_V(t)$. The driver is regarded as a transfer element with the vehicle's seat acceleration as input and the driver body acceleration as output. The resulting transfer function depends on the current driver state, i.e. in the manner of fatigue. So by monitoring the driving style as well as the driver's body acceleration changes in its driving condition can be detected. Investigations in the context of estimating the state of pilots are the basis of this strategy [10]. As a result, the estimation of the current driver condition can be expressed in the form:

$$c_D(t) = f\left(\left\|x(t) - x^N(t)\right\|, \left\|C_{St}(t) - C_{St}{}^N(t)\right\|, \left\|a_D(t) - a_V(t)\right\|\right) \quad (1)$$

As a next step mechanisms for the detection of reduced capabilities of the driver in relation to his driving task have to be developed. The goal is to give recommendations for safe driving though short or long term limitations. Therefore corresponding zones as functions of the environment vector are defined (see figure 4). The CAP's decision is then based on current driver condition $c_D(t)$ and current vehicle capability $c_V(t)$ as well as the current driving parameters like speed or total travel time and is outputted via the competence assignment to driver and vehicle $y_{c,D}(t)$ and $y_{c,V}(t)$. This competence assignment encompasses a range of measures from warnings to the driver or automatically running safety actions of the vehicle if the driver is losing his competence, i.e. by a shock.

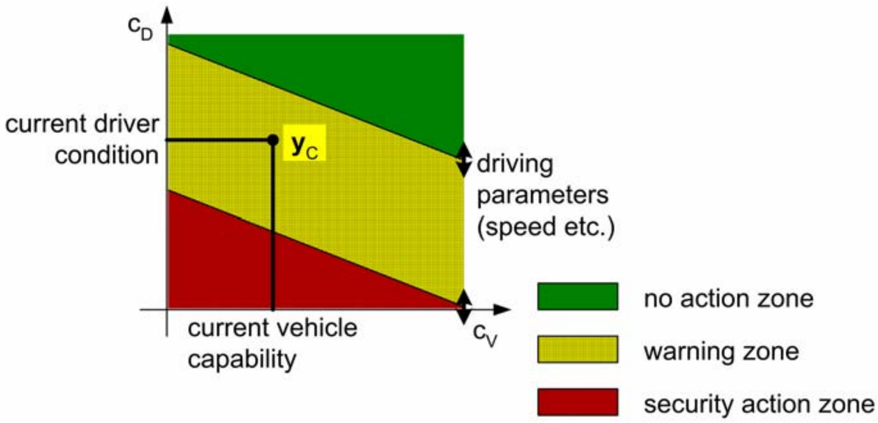

Figure 4: Determining competence assignment to driver and vehicle

5. IMPLEMENTATION ASPECTS

First experiences with an online monitoring of driver and vehicle were made in the project Superfour-in. In this project an outdoor wheelchair was equipped with a special developed surveillance technology. An onboard vehicle control center (VCC) collects technical data from the vehicle and medical data from the driver. This data is then evaluated automatically. If an emergency or a technical fault is detected, a care service center (CSC) is informed automatically. Several kinds of technical faults are recognized. For instance the motor-currents are used to detect flat tires. Furthermore the state of the hybrid power-system is monitored to predict the remaining reach. In addition the state of the driver is monitored using an interface for bio-signals. A sensor for the measurement of the heart-rate and the blood oxygen saturation was integrated. This measurement allows detecting some kind of acute cardiovascular problems. Especially for the noninvasive measurement of relevant bio-signals in a driving vehicle there are only a few suitable solutions. In the mentioned project the evaluation of the vehicle state and the state of the driver are separate tasks. According to the approach of this paper this two tasks have to be joined to get more detailed information about the state of the driver.

6. CONCLUSION AND FURTHER WORK

The task of the competence adapter presented in this work is to identify the driver and vehicle condition and then allocate competence appropriately. If a durable and/or brief competence loss of the driver cannot be balanced by the vehicle, a mission cannot be realized. Therefore, a separate emergency system has to stop the vehicle in a controlled manner. At current the appropriate models for drivers are developed and driving behavior in the different age phases is being examined.

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Authors:
Fabian Müller
Dr. Andreas Wenzel
Prof. Dr.-Ing. habil. Jürgen Wernstedt
Fraunhofer Application Center System Technology (AST), Am Vogelherd 50
D-98693 Ilmenau, Germany
Phone: +49 3677 461-140
Fax: +49 3677 461-100
E-mail: {fabian.mueller,andreas.wenzel,juergen.wernstedt}@ast.iitb.fraunhofer.de