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FACULTY OF COMPUTER SCIENCE AND AUTOMATION

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
Technische Universität Ilmenau
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A. Wenzel / A. Gehr / T. Glotzbach / F. Müller

Superfour-in: An all-terrain wheelchair with monitoring possibilities to enhance the life quality of people with walking disability

ABSTRACT

This paper presents an overview of a project in which a concept of safe mobility for walking impaired people in an outdoor environment was developed and implemented. A prototype of an innovative commercial outdoor wheelchair was equipped with a special surveillance technology which monitors the state of the vehicle and the driver and contacts a control center if an emergency or a fault occurs. The system was successfully tested in rough terrain. This project results are the basis for the further product development, like a rental system for such vehicles in touristic regions.

1. INTRODUCTION

More than 4 million people with walking disabilities live in Germany. Approximately 350000 of them have to use a wheelchair. According to the demographic trend the number of walking disabled people will grow in the next decade. People with such disabilities are handicapped in multiple areas of life. In the framework of the research project TAS-2 a consortium of the Fraunhofer Application Center System Technology Ilmenau and the Technical University of Ilmenau explored possibilities to enhance the quality of life for disabled people during their holidays in a model region in the Thuringian Forest. The main focus of this paper is put on the support for walking disabled people in outdoor activities. This paper primarily describes the work which was done to develop an intelligent outdoor wheelchair system. Recent work on this area mainly was concentrated on the tasks of adding autonomous driving functions to wheelchairs [1,4]. Further strategies for driver assistance like obstacle avoidance, intelligent path planning and convoy functions have been developed [2,3]. Most of this work has been done in the context of indoor driving. In [4] the need of developing driver assistance systems and not of autonomous driving is accentuated. According to the aim of TAS-2 to support people with walking disabilities in touristic outdoor activities, an outdoor wheelchair was equipped with a surveillance technology which allows the monitoring of the vehicle and the driver state due to the following reasons: Individuals with a walking disability are usually not able to safe themselves in the case of technical malfunctions or accidents. Moreover, this group of people often suffers from several medical limitations. Especially in the case of the poorly populated model region in the Thuringian forest an automatically autonomous surveillance technology is absolutely necessary.

2. SYSTEM DESIGN

2.1 Platform

Most of the commercial available electric powered wheelchairs are not able to drive over rough terrain or even dirt roads for relevant distances. This leads to the fact that most of the relevant touristic areas of the Thuringian Forest are unreachable. During the mentioned project several wheelchairs were evaluated. A prototype of the outdoor wheelchair SuperFour© of the company Otto Bock Healthcare GmbH did apply for the described problems. The new created system of SuperFour and the developed monitoring technology was called 'Superfour-in'. A number of innovative features of the base platform SuperFour were adopted by the Superfour-in system. The wheelchair is powered by a four wheel drive with two steerable axles. A hybrid system of accumulators and a combustion engine does provide an operation range of more then 100 km. Furthermore the wheelchair is able to overcome pitch and bank slopes up to 40 percent. The seat which is in a central position has an automatic balancing system and can be driven out of the wheelchair for an easy transfer from or to a normal wheelchair. These features of the platform provide an excellent all-terrain ability of the system.

2.2 Components

In figure 1 the general concept of Superfour-in is shown. In a so called "Care Service Center" (CSC) several of the special vehicles are supervised. This CSC can be located at a rental station for instance where it is possible for people with walking disabilities to rent such vehicles. Each vehicle has an onboard "Vehicle Control Center" (VCC). This component described later collects technical data of the vehicle and medical data of the driver. These data is automatically interpreted by the developed software of the VCC. The user interface of the VCC gives information about navigation and the vehicle state to the driver. The VCC is connected via General Packet Radio Service (GPRS) to one CSC. In case of an emergency the CSC alerts a supervisor. Because of the permanent position transmission from VCC to the CSC rescue activities can then be started very effectively.

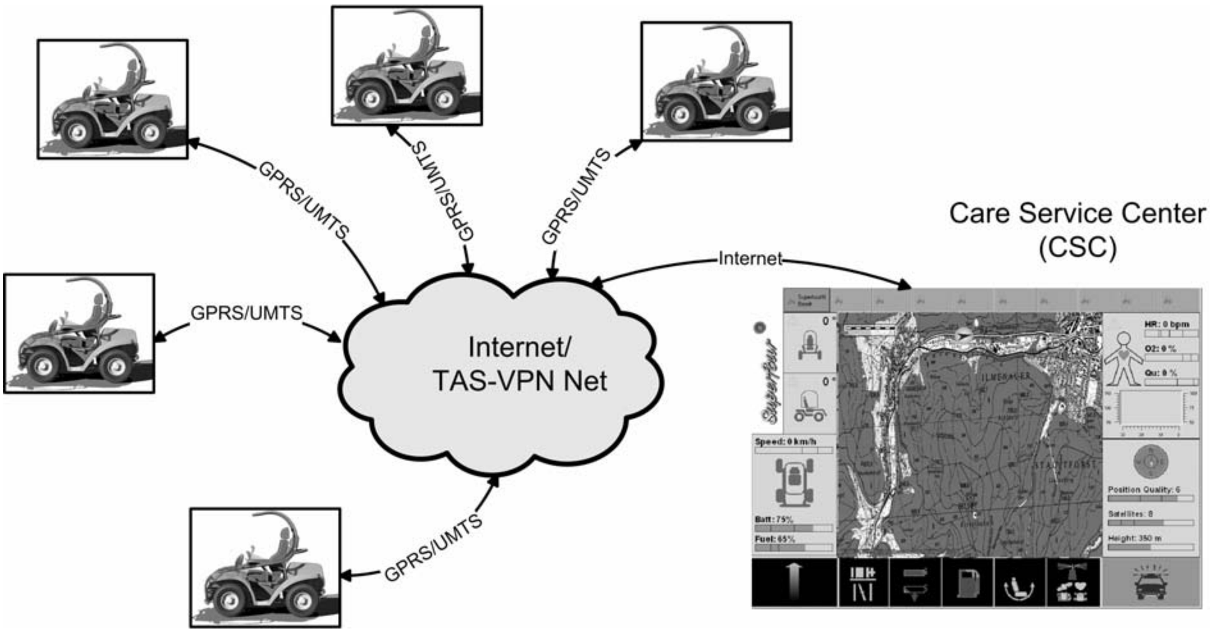

Figure 1: General concept of the system Superfour-in

2.3 Vehicle Control Center (VCC)

The structure of the developed vehicle control center is shown in figure 2. The main component is a waterproof tablet PC that runs the VCC application. This software collects the vehicle data and the medical data from the driver. The screen of the tablet PC is mounted in view of the driver so he can see the navigation information on the presented map and the state of the vehicle. The essential handling operations of the VCC are done by using the buttons on the tablet PC. According to figure 2, the vehicle information is collected in two different ways. The information about the state of the electrical drive is transmitted via a CAN-bus network so that the VCC Software can read this essential information. Some of the evaluated information is for instance the currents and the rotation speed of the four electrical engines and the state of the batteries. This information is used to detect or predict malfunctions like a flat tire, defect engine or empty battery. For the extraction of other important technical data a special embedded system was developed. This microcontroller application collects several additional sensor values. Anymore this circuit communicates via a special three wire serial bus with the control of the combustion engine of the vehicle. Values like the fuel and engine state are acquired on this way. An important information in this context is the current longitudinal and transversal angle of the vehicle. By the use of this information the VCC warns the driver prior to a rollover or it is able to detect that a rollover has happened. The mentioned embedded system collects all these data and sends it cyclically via an USB-interface to the tablet PC where the information is interpreted by the VCC-Software. In addition the current position of the vehicle is determined by a GPS receiver and is sent to the VCC. Not only technical measurements are evaluated by the VCC. The developed software provides an interface for bio-sensors. In this way biosensors with cyclical or event-driven messages can easily be integrated into the system. For the application on a vehicle, only noninvasive robust measurements are considered. Furthermore these measurements should be easily applicable to the driver. Measurements of cardiovascular parameters are relevant for many diseases. Therefore as an example application a photopletysmography sensor was integrated. The evaluating processor unit of this sensor provides information about current heart rate and the arterial oxygen saturation of the driver. Additionally a parameter which represents the current signal quality is available. Some kind of medical problems, like tachycardia can be automatically detected in this way.

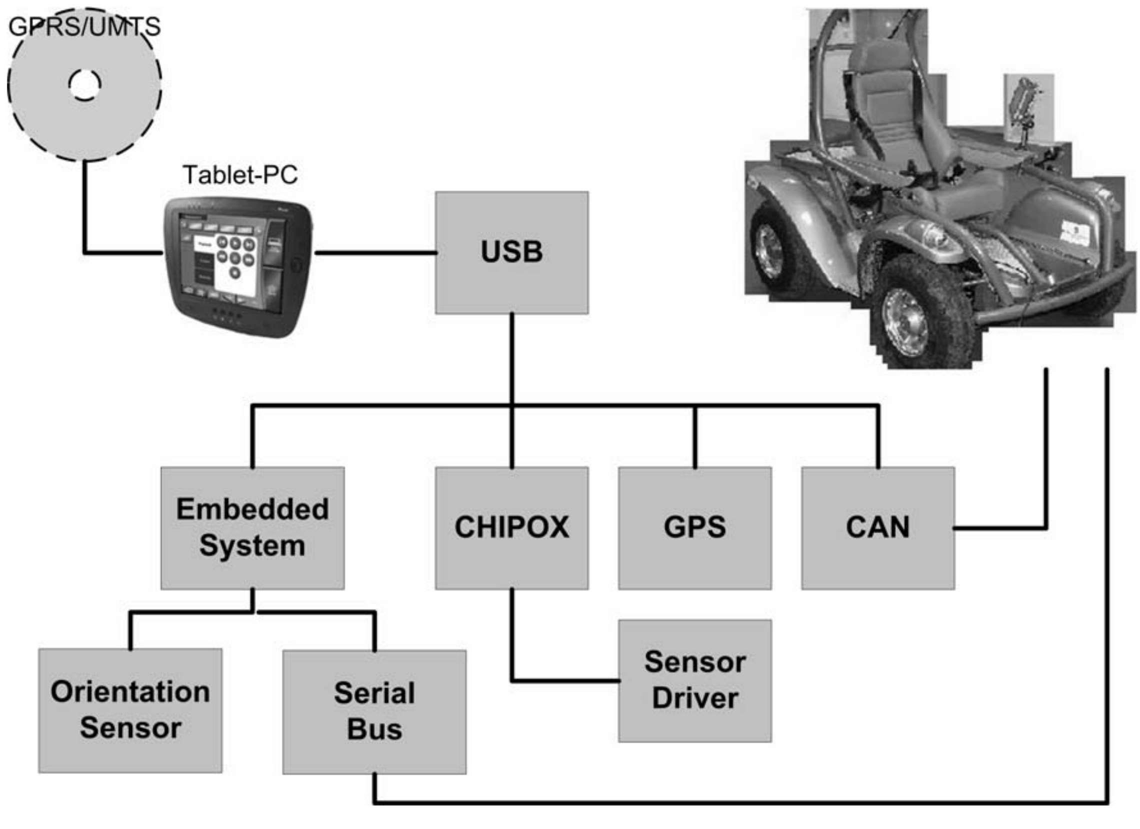

Figure 2: Structure of the Vehicle Control Center (VCC)

2.4 Care Service Center (CSC)

The developed CSC consists of a PC or Laptop which needs an internet connection and a special CSC-Software. These systems can be located for example at a rental station for Superfour-in systems or at a hotel reception desk. When the software is started it waits for incoming connections of VCC's. Once the communication is established the position of the relevant vehicles is shown on a map. By selecting a special vehicle, the current state of the vehicle and the medical data of the driver can be observed. If some of the connected VCC's report an automatically detected dangerous state or if one of the drivers sends an emergency call the system warns the supervisor acoustically and marks the relevant system in the map. Then the supervisor can try to contact the driver or if some kind of emergency has happened, he can initiate the recovery actions.

3. TEST RESULTS

Figure 3: The system Superfour-in outdoor tests

The developed system Superfour-in was sufficiently tested by different people with and without walking disabilities in different situations in the above mentioned region. The tests were partially carried out under snowy conditions. Especially the all terrain abilities and the weatherproofness met the demanded requirements. The system showed a good behaviour in both, road traffic and off road situations (Fig. 3). There are only a few available solutions for a mobile measurement of relevant medical data at the moment. This area of medical equipment technology in our opinion needs further research and development. It can also be stated that localisation whit standard GPS technology offers good suited solution for the traffic on mapped public roads, but is often not exact enough regarding to the localisation of smaller objects on off road terrain where only rough mapping is available. Therefore after some testing more precise GPS-receivers with dead reckoning had to be implemented. The area-wide availability of GPRS has to be guaranteed in every region where the system is intended to be used. During the tests in some areas there was only a weak GPRS-network available. In certain situations, it may be helpful to negotiate with the network providers or to take into account the usage of backup systems for critical areas based on narrow band radio data transmission. Such systems are commercial available and have been successfully evaluated.

4. CONCLUSIONS

The presented system Superfour-in was developed by equipping a prototype of a commercial hybrid powered outdoor wheelchair with a special surveillance technology. The system consists of an onboard vehicle control center which monitors the state of the vehicle and the driver. Furthermore the vehicle control center supports the user by navigation and with other relevant information. The developed care service center software allows to track and to support several vehicles. The whole system was successfully tested by impaired and non-impaired people under rough outdoor conditions. The results of this work are the fundament for the development of new touristic services especially for people with walking disability.

5. ACKNOWLEDGMENT

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Authors:
Dr. Andreas Wenzel
Achim Gehr
Thomas Glotzbach
Fabian Müller
Fraunhofer Application Center System Technology (AST), Am Vogelherd 50
D-98693 Ilmenau, Germany
Phone: +49 3677 461-144
Fax: +49 3677 461-100
E-mail: {andreas.wenzel,achim.gehr,thomas.glotzbach,fabian.mueller}@ast.iitb.fraunhofer.de