CEmACS Executive Summary, Month24

Complex Embedded Automotive Control Systems

KEYWORDS: Automotive control, accident mitigation, vehicle dynamics control, state observation, experimental vehicles

Introduction

The high level of complexity in automotive systems requires a new approach to design. Moreover, to achieve higher performance and increased safety a coordination of different automotive control systems is required.

Objectives

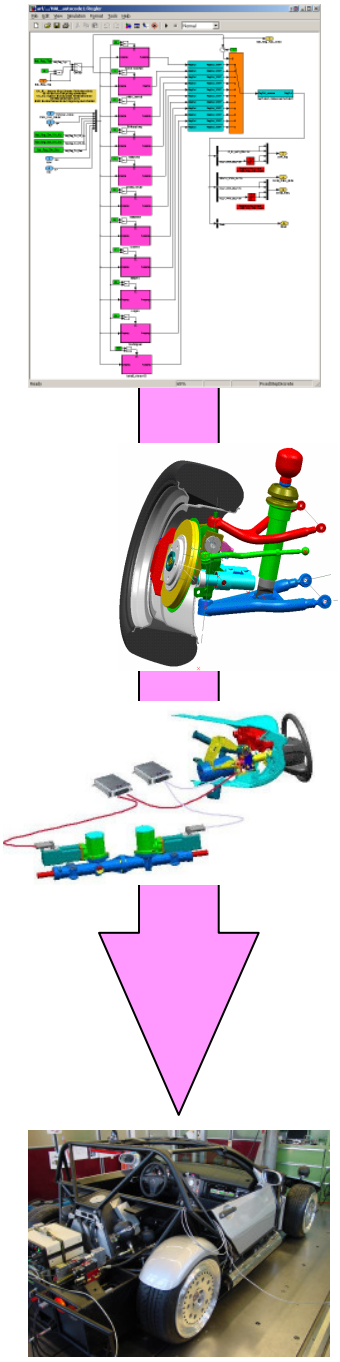
The objective of CEmACS is to contribute to a systematic, modular, model-based approach for designing complex automotive control systems. The Specific Target Research Project is aimed at combining research into the theory of multivariable control and nonlinear observers with a selection of novel prototype automotive control applications.

The basic research topics of CEmACS include classical multivariable control analysis and design techniques (in particular for high performance decentralised control systems in the presence of communicational time delays), hybrid and nonlinear and adaptive control, and observers with global convergence properties.

Control and observer designs will be evaluated using two real-life benchmark integrated chassis control design applications. These are

(i) vehicle dynamics control for active safety (roll-over mitigation and, as a long-term goal collision avoidance by active steering),

(ii) multivariable control design for ride and handling using multiple actuators (Generic Prototyping).



For the evaluation prototype experimental vehicles will be provided by one of the industrial project partners. The control approaches developed within the project will be implemented in the experimental vehicles and validated using a specified set of test manoeuvres. The systematic experimental validation will provide feedback for the further development of the basic research and control system design parts of the project.

Expected Results

The project will provide new strategies, algorithms and tools for systematic and accurate design prototyping and control of complex distributed systems with the main focus on advanced control for embedded automotive systems.

The Project objectives are well integrated with the current R&D activities of the industrial partner and the automotive industry in general; this will enable an efficient industrial exploitation of the CEmACS results.

Partners and their role

DaimlerChrysler Research and Technology acts as the project coordinator, provides the specifications for the control and state estimator design and provides the experimental vehicles and the infrastructure for the evaluation of the resulting control systems.

Lund University is responsible for basic research on hybrid control and the roll-over mitigation part of the project.

Glasgow University is coordinating the development of control design methods and designs the collision avoidance control.

SINTEF is developing vehicle state estimation techniques and will be in charge of the overall system integration.

National University of Ireland Maynooth will carry out the multivariable control design for integrated chassis control.

CEmACS

CONTRACT NUMBER
IST – 004175

FULL NAME
Complex Embedded Automotive Control Systems

TYPE OF PROJECT
Specific Targeted Research Project

PROJECT PARTICIPANTS
DaimlerChrysler AG, Germany
Lund University, Sweden
Glasgow University, United Kingdom
SINTEF Electronics and Cybernetics, Norway
National University of Ireland Maynooth, Ireland

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PROJECT WEBSITE
http://www.hamilton.ie/cemacs/

BUDGET
Total cost: 2.3 MEuro
Funding: 1.5 MEuro

TIMETABLE
Starting date: 1. August 2004
Duration: 36 months

This project is part of the portfolio of the

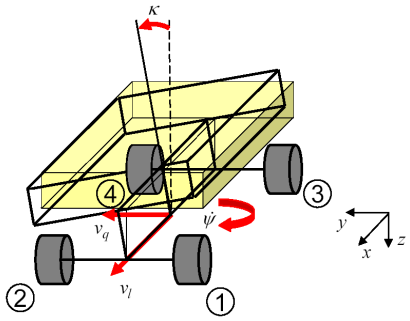
Embedded Systems Unit – C3
Directorate General Information Society

For more information please check:

http://www.cordis.lu/ist/directorate_c/ems/

Work performed

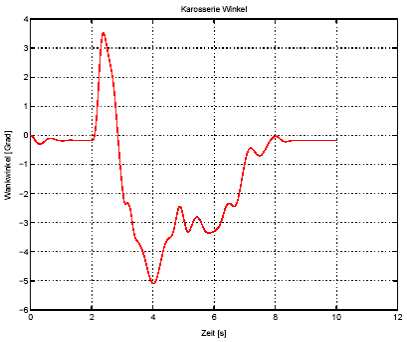
Work in the second reporting period was mainly dedicated to control system specification.
Following the specifications of the various test vehicles the specification of the roll-over avoidance, collision avoidance, 4-wheel steering based lateral control and side-slip angle observer was carried out. Preliminary control designs were tested in simulation. The preliminary nonlinear observer design was tested with experimental data.

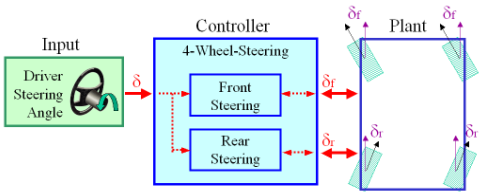


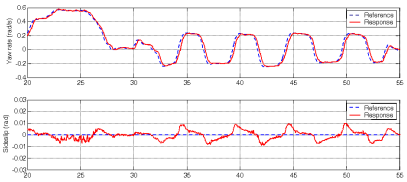
Achieved Results

The project is running according to the workplan as far as the achieved results are concerned.
The main highlights for the third reporting period can be summarised as follows:

- *Controllers for roll-over avoidance and collision avoidance implemented and tested in simulation.*
- *Integrated chassis controller tested in simulation.*
- *Components of the Integrated Chassis Control system (yaw-rate control, side-slip control and roll-angle control) were successfully tested in the car.*
- *Final report on the control approaches with focus on high performance decentralised multivariable control, control allocation and switched control.*
- *Final Report on vehicle state observation including further results on the benchmark of side-slip angle observers based on experimental data. An S-class and an M-class based test vehicle were used to carry out skidding manoeuvres under winter low-friction conditions in Sweden. The data was used to validate the observer design for very large side-slip angles. Also, a run-time analysis of the real-time implementation of the nonlinear observer and comparison with an existing Kalman filter was carried out. The analysis showed the considerable reduction of in computational complexity of the new approach in comparison to the Kalman filter approach.*
- *Controllers and observers integrated in real-time systems.*







Intentions for Use and Impact

The Project objectives are well integrated with the current R\&D activities of the industrial partners and the automotive industry in general; this will enable an efficient industrial exploitation of the CEmACS results. With a test vehicle for roll-over mitigation there will be improved chances for dissemination of the results of roll-over mitigation.
Dissemination of generic results has continued as planned. Since the start of the project 14 papers have been submitted to peer-review journals, of which 6 papers have been accepted for publication. 9 papers have been submitted to major conferences of which 2 have been accepted and 4 published.
The CEmACS workshop on theory was hold in Lund June 8-9 2006 as a joint event with the FP6 network HYCON strengthening collaboration between the projects. The consortium has established contacts to the projects SPARC (Secure Propulsion using Advanced Redundant Control) and HYCON.