CoCar-The instrumented Test Vehicle of the Living Lab Automotive

with applications to environment interpretation and autonomous driving

J. Marius Zöllner, Marcus Strand
IPG Apply and Innovate, 18. 09.2012
The FZI

About us

- Foundation of the state Baden-Wuerttemberg
- Member of Innovationsallianz Baden-Württemberg and Technologieregion Karlsruhe
- Innovation hub in Baden-Wuerttemberg for information technology
- Innovation partner of the Karlsruhe Institute of Technology
- Medium-sized provider of research services

Figures and facts 2011

- Overall budget: 16.4 M €
- Researchers: 150
- More than 170 projects, orders directly from the industry and publicly funded joint projects
- Certified Quality Management System according to ISO 9001; departments with applied research in medical products are also certified according to ISO 13485
FZI’s formula for success: a strong network

Innovative forms of cooperation
e.g. Shared Professorship

Close connection to KIT and its students

Knowledge, Transfer

FZI’s competence
Mastering a balancing act between research and practice

Research
Partner institutes at KIT

Practice
Spin-offs and partners

Impulses

Interdisciplinary network of employees

Spin-offs from FZI are international technology leaders

FZI Friends’ Association with ca. 100 industrial companies

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Our strength:
Interdisciplinary research divisions

19 directors in our research departments from four faculties

Head of departments
ISPE – Intelligent Systems and Production Engineering

- Development and testing of methods, tools and design processes realizing software-driven technical systems
- Interdisciplinary solutions for the design, control and realization of technical systems
Intelligent Systems and Production Engineering

**Directors**

Prof. Dr.-Ing. Rüdiger Dillmann  
Prof. Dr. Dr.-Ing. Dr. h. c. Jivka Ovtcharova  
Prof. Dr. Wolfgang Rosenstiel  
Prof. Dr. Hartmut Schmeck  
Prof. Dr.-Ing. Christoph Stiller  
Prof. Dr.-Ing. J. Marius Zöllner

**Associated director**

Prof. Dr. Oliver Bringmann

**Head of department**

Dr.-Ing. Marcus Strand

**Forschungsbereich ISPE**

*Technologies for technical systems*

**Heads of units**

Dipl.-Inform. Birger Becker  
Dipl.-Ing. Arne Rönnau  
Dipl.-Wi.-Ing. Viktor Schubert  
Dipl.-Inform. Alexander Viehl  
Dipl.-Inform. Julius Ziegler

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## Our services

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<th>Contract Research and Development</th>
<th>Analysis and Consulting</th>
<th>Training and Guidance</th>
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<tr>
<td>• Deployment and addition of R&amp;D expertise for SMEs</td>
<td>• Support in product development</td>
<td>• Introduction of new application systems</td>
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<td>• Planning and conceptual design of joint projects on national and international level</td>
<td>• Market potential and product opportunities</td>
<td>• Workshops about state-of-the-art technologies</td>
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<td>• Development of innovative solution scenarios</td>
<td>• Workflows, processes, and structures</td>
<td>• Current methods and tools</td>
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<td>• Support in product development – from design to prototype</td>
<td>• Product and service concepts</td>
<td>• Feasibility studies</td>
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FZI Living Labs: basis for integrated research service offers

- Participative research of industry, science and end users
- Concentrated provision of interdisciplinary scientific know-how
- Holistic testings of innovative concepts for new software-based products and services
- Practical tests before market-launch for applications in the field of engineering and IT
- Feedback of market knowledge for further research
- Triggering innovation impulses
- Moderation between technology partners and user groups
- Room for open innovation
FZI Living Labs: key role in the innovation process

PARTNER

Science

Industry

User

FZI Living Labs

Technologie-, Evaluierungs- und Integrationsplattform Open-Innovation-Netzwerk

AAL

Mobile IT/SatNav

Automotive

Service Robotics

Integrate

Include users

Evaluate

APPROACH
House of Living Labs: scientific services to fit custom requirements

Approach will generate a inspiring ecosystem of partners and customers

House of Living Labs as an „Open Innovation“-network

Providing of a broad portfolio of enabling technologies and innovations at interfaces

House of Living Labs as a platform for technology

House of Living Labs as a platform for evaluation

Infrastructure and suitable partners allow the evaluation of solutions

House of Living Labs as a platform for integration

Developed research environments allow a fast technology integration
FZI Living Labs

Eight FZI Living Labs:

- FZI Living Lab smartAutomation
- FZI Living Lab smartEnergy
- FZI Living Lab smartHome
- FZI Living Lab smartMobility
- FZI Living Lab Service Robotics
- FZI Living Lab Ambient Assisted Living
- FZI Living Lab Automotive
- FZI Living Lab mobileIT/SatNav
FZI Living Lab Automotive: Driving Simulator

- Driving dynamics simulation
- Generation of virtual sensor data
- 270° panoramic projection
- Integration of ADAS
- Force Feedback steering
FZI Living Lab Automotive: The instrumented Test Vehicle

- Multicore Computation Systems
- Integrated Sensors
  - PMD Camera front and rear
  - Driver observation cameras 2D/3D
  - Front/Rear cameras
  - Localization system
  - 3 IBEO Laser (2 front, 1 rear)
  - Vital sensors
- Several Communication and Power Interfaces
  - 12V / 220V
  - Firewire
  - USB
  - Ethernet
  - MOST
  - CAN
- Several Displays
  - MMI Display
  - Combi Display
- Actuators for autonomous driving
- Continuous integration of algorithms
Cooperations within the FZI Living Lab Automotive
Perceiving and Interpretation
Static and Semi-Static Environment

- Sign recognition, signpost and additional signs
  - Pre-processing
  - Feature based segmentation
    - Form based, geometrical properties
    - Colour based, retro reflection and illumination based
  - Sub-segmentation of complex signs
  - Pictogram classification by cascaded SVM
  - Text recognition
  - Tracking and temporal fusion

- Relevance estimation
  Assignment to lanes
  - Fusion with lane tracking
  - Using a-priori knowledge about signs
  - Probabilistic approach (Mixture of Gaussian)
Perceiving and Interpretation
Dynamic Objects

- Combining different sensor systems
  - 3D TOF, 2D Video, Radar, Stereo
  - 3D segmentation (U/V disparity or TOF ),
  - 2D detection by symmetry, shadow
  - Viola Jones detector
  - Gabor-features and SVM classification
  - Kalman tracker

- Detection during dusk and at night
  - Adaptive Gauss filtering
  - Hypothesis generation
  - Hypothesis verification by classification (coming soon)

- (First) Manoeuvre state detection
  - Breaking, lane changing
Perceiving and Interpretation
Dynamic Objects

- Blind spot detection
  - Appearance based hypothesis generation (symmetry, shadow,…)
  - HOG feature based hypothesis verification (classification)
  - Optical flow (near field tracking)

- Pedestrian detection
  - PMD based segmentation
  - Vision based – Ada boost classification
  - Tracking
  - Probabilistic Interpretation
Idea behind Individual Mobility Assistance

- Assist users during shopping, while visiting exhibitions, ...
- Assist users from door to door and from person to person
- Project requirements:
  - Individual public transportation platforms
  - Personalized localization, navigation and navigational assistance
  - Work seamlessly indoor and outdoor
- Hardware components:
- ToF sensors
  - Long-range PMD camera
  - Short-range SR4000 camera
- Video sensors
  - wide angle lens video sensor
- Onboard computers & display
- Additional power units
Complex Scene Understanding

- Decide which manoeuvre is the safest, most efficient, etc.
- Support user to perform safe manoeuvre
Driver Observation

- Tracking the driver's head movement
SLAM

- Localisation in unknown environments using laser scanner data
Autonomous Driving

- **CoCar- The instrumented test vehicle of the FZI Living Lab Automotive**
Thank you for your attention…