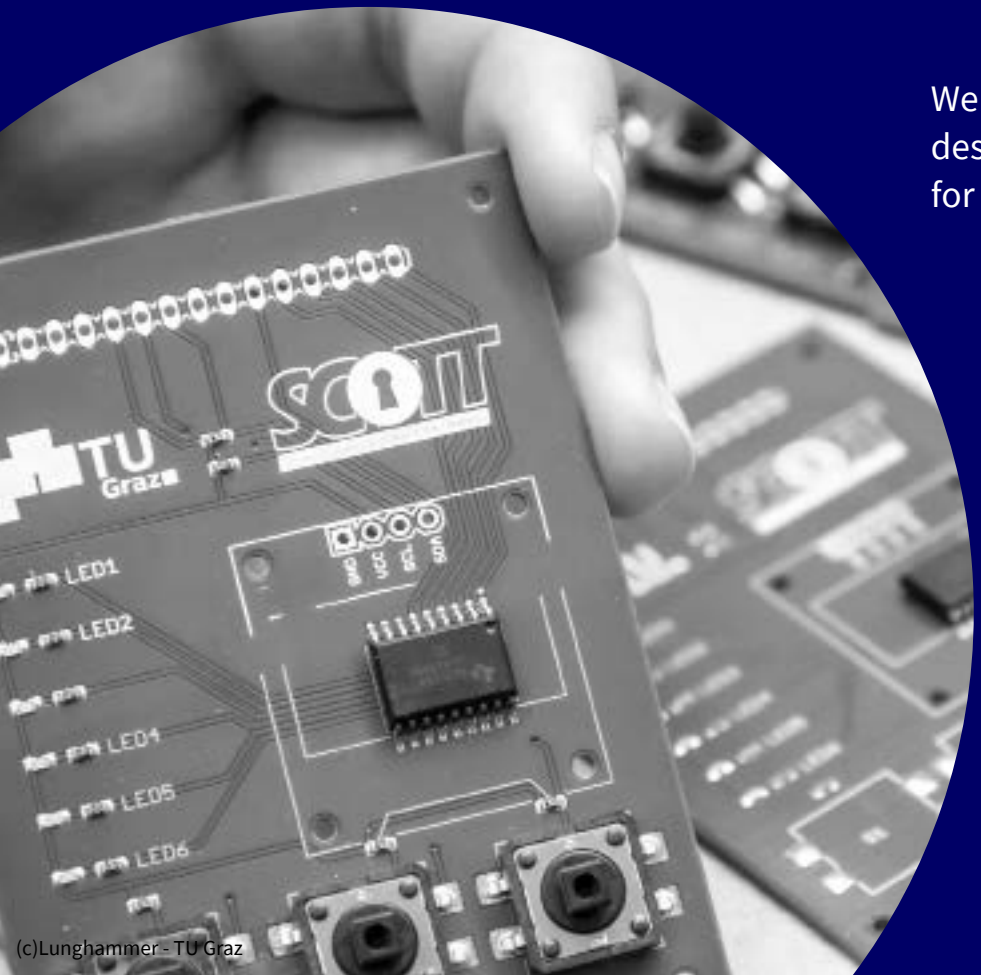
INSTITUTE OF TECHNICAL INFORMATICS

Bachelor / Master Thesis Topics

WS 2020/21

INSTITUTE OF TECHNICAL INFORMATICS

We offer research and education on modern networked embedded systems (such as Internet of Things and Cyber-Physical Systems) with focus on software, hardware, and networking. Our working groups make significant contributions to improve dependability, real-time properties, safety, security, and efficiency of these systems to enable novel applications.



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We are involved in numerous collaborations with industry partners. Besides funded research projects, we also collaborate directly with industry, for example by jointly supervising masters and PhD theses.

The education focus is on foundations of Computer Engineering, Real-time Systems, Distributed Systems, Functional Safety, and Pervasive Computing. The institute significantly contributes to the courses of study in Information and Computer Engineering (previously Telematics), Electrical Engineering, Informatics, and Software Engineering.

RESEARCH AREAS

Networked Embedded Systems

The Networked Embedded Systems working group, headed by Prof. Dr. Kay Römer, investigates design, implementation, and test of sensor networks, Internet of Things, and Cyber-Physical Systems with special emphasis on networking and software engineering aspects.

Embedded Automotive Systems

The Embedded Automotive Systems group, headed by Prof. Dr. Marcel Baunach, investigates the design, implementation, and test of operating systems, multi-core architectures, and wireless networks within the automotive domain.

Hardware / Software-Codesign

The HW/SW codesign group, headed by Ass.-Prof. Dr. Christian Steger, deals with embedded systems, HW/SW codesign, and power awareness.

Industrial Informatics

Industry oriented topics. Tackling needs and challenges in complex and critical systems engineering, practical approaches to Functional Safety and Secuity, technology, quality, process improvement, and compulsory standards. Plus dedicated industry courses on Functional Safety and Automotive Integrated Quality.

NETWORKED EMBEDDED SYSTEMS GROUP

Modern embedded systems typically consist of multiple computers that are connected by a wireless or wired network. Sensor networks, Internet of Things, Cyber-Physical Systems are all examples of this type of technology. The Networked Embedded Systems working group, headed by Prof. Dr. Kay Römer, investigates design, implementation, and test of such systems with special emphasis on networking and software engineering aspects. Typical challenges that need to be tackled are the openness and dynamicity of such embedded networks, resource and energy constraints, harsh environmental conditions, and the need for dependable operation despite these difficulties. The working group focuses on experimental research, where concepts are transformed into realistic prototypes that are used in experiments to assess the properties and performance of the concepts.

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Networked Embedded Systems Group

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Research Area 1: Dependable Wireless IoT Systems

Networks of low-power wireless sensors and actuators are becoming an integral part of our daily life: hidden in our homes, cities, and cars, worn on our wrists, integrated in our clothes. They are a fundamental building block of the Internet of Things (IoT) and therefore need to operate efficiently and reliably.

The research activities in the “Dependable Wireless IoT Systems” subgroup aim to analyze and improve the performance of low-power wireless technologies and protocols used to build present and future IoT systems, with the ultimate goal of increasing their dependability and real-world applicability.

We are always looking for highly motivated and brilliant students interested in doing a project or thesis on our research topics. We typically define the concrete topic after a short meeting with the student, in order to adjust the project/thesis to his/her interests and skills. For concrete openings at the moment, please check here and here.

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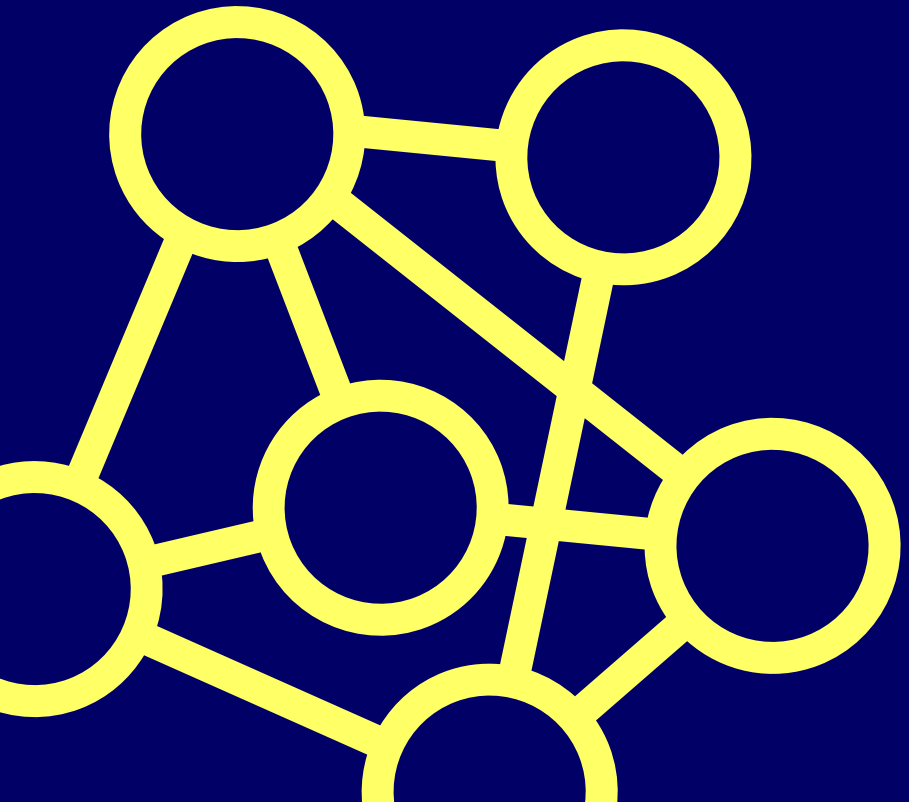
Markus Schuß markus.schuss@tugraz.at [Focus on Benchmarking IoT Systems]
Max Schuh schuh@tugraz.at [Focus on Ultra-Wideband Localization]
Michael Spörk michael.spoerk@tugraz.at [Focus on Bluetooth Low Energy]
Michael Stocker michael.stocker@tugraz.at [Focus on Ultra-Wideband Localization]

Research Area 2: Embedded Information Processing

Today a wide range of sensors integrate with IoT devices to measure their surrounding contexts. As the number of integrated sensors and their complexity grows, so are the amounts of data they produce and need for this data to be processed. The state-of-the-art computational models that, for example, recognize a face, detect events of interest, track user emotions, or monitor physical activities are increasingly based on deep learning principles and algorithms. Unfortunately, deep models typically exert severe demands on local device resources, and this conventionally limits their adoption within mobile and embedded platforms. Our group works on new sensing concepts based on machine learning models, and on solving the challenges when running these models on embedded and mobile devices.



Dr. Olga Saukh saukh@tugraz.at [Group Leader]
Cao Nguyen Khoa Nam cao.nam@tugraz.at [Focus on pollen sensing and modelling]
Rahim Entezari entezari@tugraz.at [Focus on embedded deep learning]
Franz Papst papst@tugraz.at [Focus on privacy of IoT data]

Research Area 3: Cognitive Products and Production

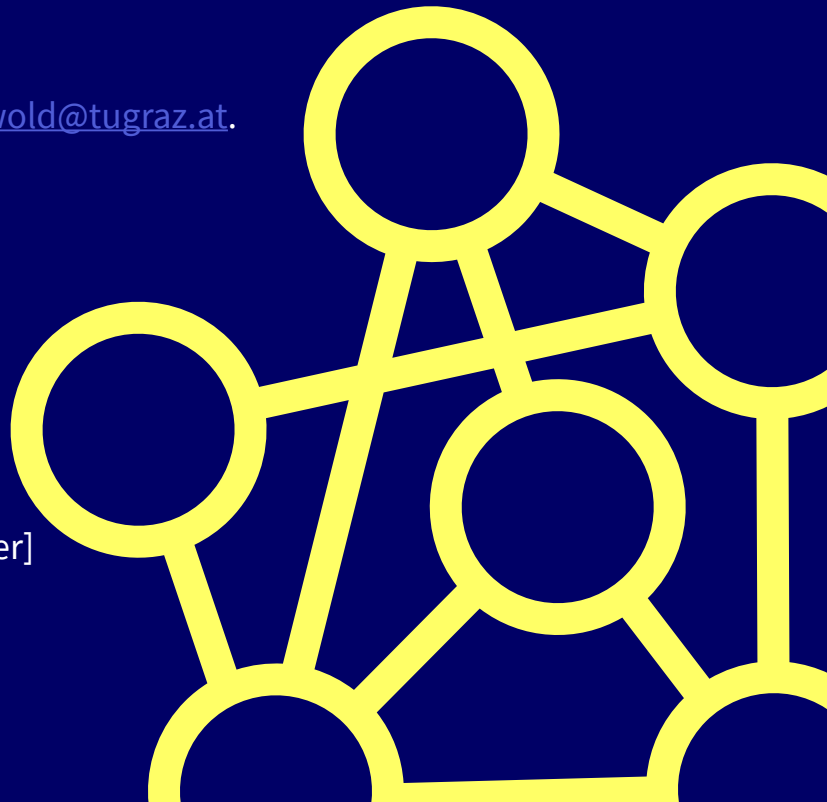
Bringing cognition into products requires dependable and low-cost sensing, networking, and software platforms. These building blocks will allow the design and realization of cognitive products, where the “cognition” denotes a products ability to adapt and its functionality across the whole product lifecycle in order to maximize customer satisfaction, product quality and sustainability, and to minimize production overheads.

Within this area we study and investigate technological building blocks required for future products and production systems and demonstrate their applicability by realizing case studies of cognitive products.

Available Topics:

- Implementing and evaluating a WiFi Direction Finder (contact leo.happbotler@tugraz.at)
- Tools for model-driven analysis for industrial processes (contact katarina.milencovic@pro2future.at)
- Implementation of a Matlab Simulink Bluetooth Low Energy (BLE) Model for System and Antenna Evaluation (contact Daniel.kraus@pro2future.at)

We are always looking for highly motivated and brilliant students. Please contact kdiwold@tugraz.at.



Dr. Konrad Diwold kdiwold@tugraz.at / konrad.diwold@pro2future.at [Group Leader]
Katarina Milenkovic katarina.milenkovic@pro2future.at [Focus on data analytics]
Daniel Kraus daniel.kraus@pro2future.at [Focus on RF antenna design]
Leo Happ Botler leo.happbotler@tugraz.at [Focus on localization]

EMBEDDED AUTOMOTIVE SYSTEMS

The EAS group aims on fundamental and applied research in highly dependable embedded systems with mixed real-time demands. Examples include electronic control units for smart, networked and autonomous vehicles, advanced robotics, and the Internet of Things. These application domains are also expected to bring forth the most disruptive core technologies for the next decade. Considering the design, implementation, test, and maintenance of such systems, a holistic view on the hardware (processor architectures), software (operating systems/applications), and networks (interfaces) reveals a large variety of exciting challenges and projects.

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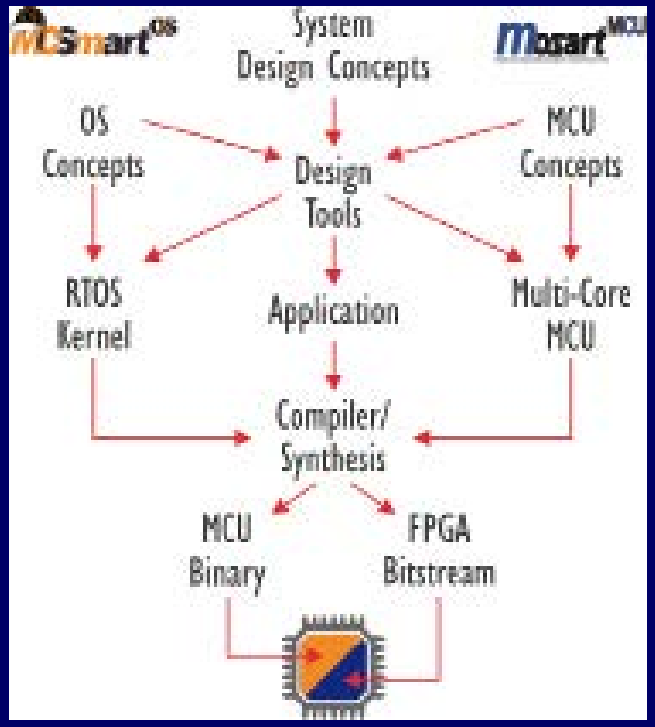
Research Area 1: Hardware-Design / Embedded Multi-Core Architecture

This area offers the opportunity to get a deep understanding in the design and implementation of MCU architectures, including single- and multi-core as well as FPGA-based soft cores and COTS ASICS:



- Code and logic synthesis in hardware and software
- Hardware resource sharing for multi/many-core
- Hardware support for low-level software
- MCU self-supervision and runtime profiling
- Hardware-assisted process synchronization
- Automatic hardware/software interface design

Tools: FPGAs, HDL, MCUs, C/C++, Assembly, mosartMCU, RISC-V

Open Topics:

- **Hardware support of OS features**
  Work together with OS developers to accelerate features through HW/SW co-designed solutions.
- **Compression of in-vehicle data streams**
  Recording and storage of complete ECU communication for driving analysis. In cooperation with AVL List GmbH.
- **More can be tailored to your interests**

Research Area 2: Software-Design / Real-Time Operating Systems

This area allows you to dig deep into operating system and basic software concepts for embedded real-time systems, and to support us in creating a versatile kernel for various application domains:

- Design and implementation of a novel embedded operating system
- Multi-core concepts and software partitioning for handling dynamic workloads
- Model based OS design for automatic porting to various MCU architectures
- Verification concepts for OS kernels and low-level software
- Automatic interfacing of synthesized hardware extensions
- Basic software and systems generation for automotive and IoT applications

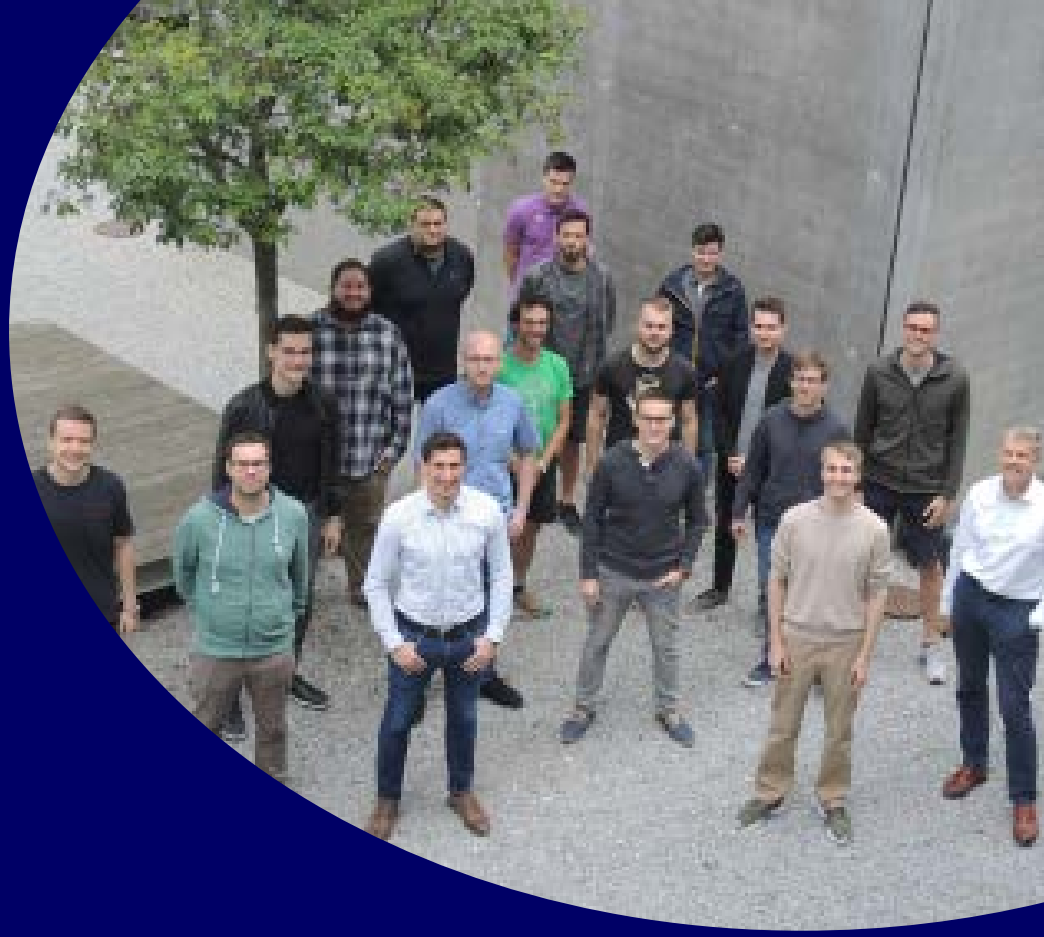
Tools: C/C++, Assembly, ADA, MCSmartOS, general purpose and domain specific development tools and hardware (automotive ECUs, IoT devices, etc.)

Open Topics:

- **MCSmartOS goes {insert your favorite architecture}**
  Porting our existing OS to an embedded computing architecture of your own choice.
- **Embedded Systems Dynamic Composition**
  Deepen your knowledge in the ELF binary format, linking, loading and OS features to support modular updates.
- **Correct OS kernels with ADA**
  Implementation aspects of OS kernels with provable properties using the ADA and SPARK programming language.
- **More can be tailored to your interests**

HARDWARE / SOFTWARE-CODESIGN GROUP

The HW/SW codesign group at the Institute for Technical Informatics deals with embedded systems, HW/SW codesign, and power awareness. Design of embedded systems can be subject to many different types of constraints, including timing, security, power consumption, reliability, and cost.



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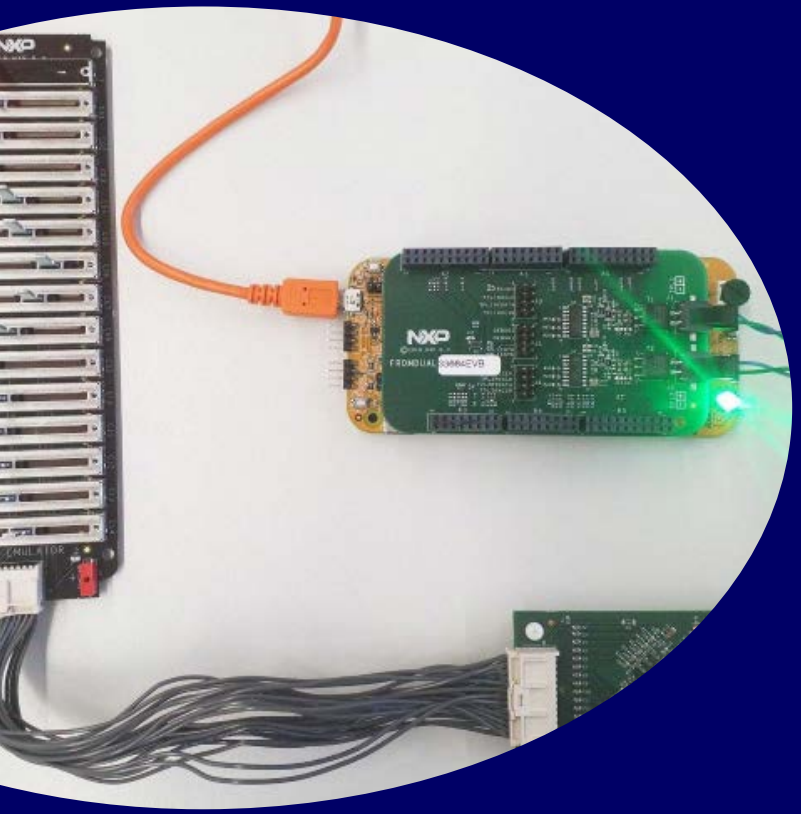
Research Area 1: SEAMAL BMS
NFC and Security related Topics in domain of
Battery Management System

in cooperation with NXP Semiconductors



Battery Management Systems (BMS) present systems found today in many applications, e.g. in vehicles, where they are used to control the health status, as well as the load/unload of battery cells. They present a relatively new and open research field.

TU Graz, together in cooperation with NXP, is interested in devising novel solutions in the area of module communications, i.e. switching from wired to wireless technology, particularly NFC. This opens many new possibilities which include wireless updates and configurations, better sensor coverage, easier module maintenance, etc. These changes should be supported with the latest trends in security.

The goal is to allow integration of new communication technologies, while at the same time ensuring the protection of the data confidentiality and integrity.

Project Topics:

- NFC-based system configuration and monitoring
- Secure communication between a BMS MCU with internal and external components and services
- Anti-Counterfeiting: Battery pack module identification using wired or wireless interfaces
- Design and implementation of a secure BMS battery cells profile history storage

Research Area 2: SMARTY
Smart Freight Mobility

in cooperation with Innofreight

Rail freight is struggling with constantly losing market share. Reasons for this loss are outdated technology, inadequate customer orientation, high level of inflexibility and missing sustainability concerning the business models. In addition, the use of wagons is usually characterized by very low productivity. Rail freight transport faces the great challenge of creating the turnaround as quickly as possible in the direction of more competitiveness and future viability.

‚SMARTY' sets the next and most challenging steps for innovation. Development of a cooperative model of resource utilization in form of a sharing platform for several customers.

Project Topics:

- Rail wagon tracker based on Thingy91 prototyping platform for cellular IoT using NB-IoT, LTE-M and GPS
- Real-time testbed for smart services for freight logistics

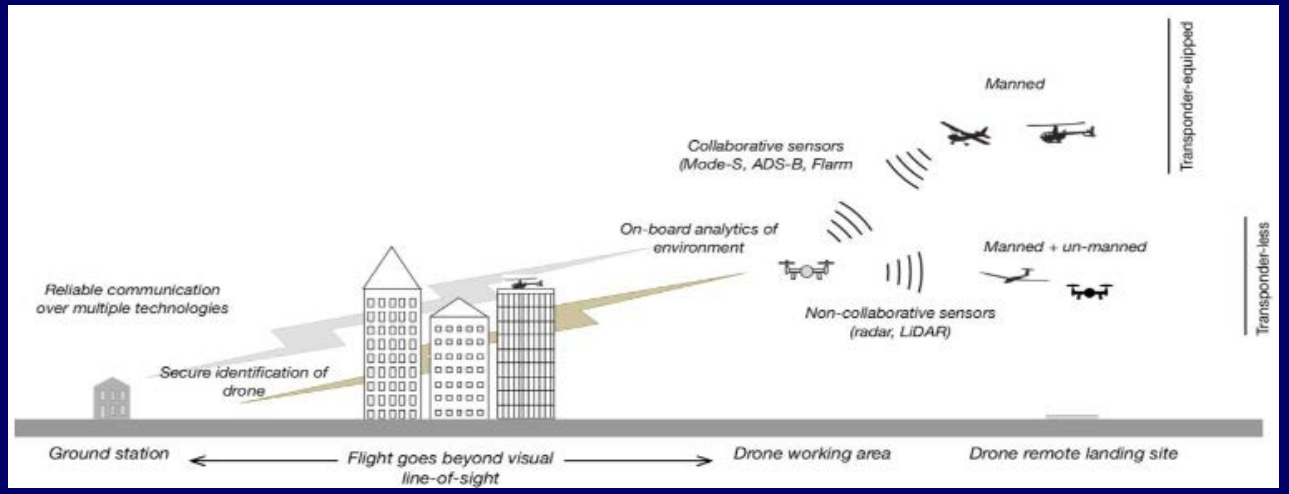
ADACORSA

in cooperation with Infineon

Research Area 3: ADACORSA
Airborne data collection on resilient system architectures

Autonomous drones have to be aware of their surroundings in order to avoid unintentional interaction with them. To achieve this they have to sense their environment at a very high resolution to detect trees, branches, electric lines and the various other low altitude occlusions that occur in the real world. In future it might be a common sight to see autonomous drones flying beyond the visual line of sight (BVLOS) in very low level (VLL) airspace.

The ADACORSA project is working on functionally safe sensors and sense-and-avoid systems that should aid drones to achieve such challenging tasks. Designed with low weight, size and cost in mind, the sensors and systems are intended for drones flying in very low level airspace.



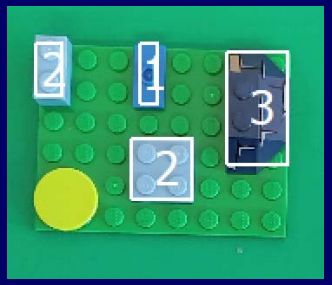
Project Topics:

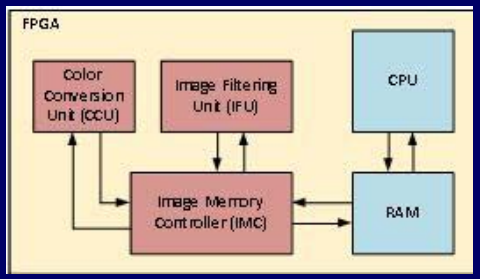
- Reactive Functional Safety for Drones
- Data Confidence in Sensor Systems
- Homomorphic Encryption scheme for Critical Drone Sensor Data

Research Area 4: Sensor SoC
SoC topic in the area of image processing

in cooperation with ams AG

Embedded image processing and analysis close to the image sensor is gaining more and more momentum since it allows to reduce required network bandwidth. It enables significant efficiency improvement in product quality management for industrial use cases. The images are processed with different algorithms and analyzed. With the processed data, product quality inspection in industrial use cases are possible. Image processing in a smart image sensor not only comes with benefits but also includes technical challenges regarding processing time, area and power.





Project Topics:

- Semi-automatic Test Data Generation
- Co-Processor for Image Processing or instruction set extension for RISC-V

INDUSTRIAL INFORMATICS

The Industrial Informatics working group is tightly cooperating with industry to tackle the needs and challenges in technology, process improvement, and new compulsory standards.

While the complexity increases in products and solutions for the automotive, automation, and IT domains, development cycle times are continuously shrinking. System development by singular domain specialists is no longer sufficient. Systems have to be engineered in integrated design processes across distributed supply chains, keeping track of changes in an agile manner. The group focuses on general functional viewpoints and system-wide feature thinking.

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Research Projects:

The Industrial Informatics Group is involved in several research projects, which could greatly benefit from students who are enthusiastic and motivated to take over some tasks and solve sub-problems in order to advance the projects further.

Research Area 1: Communication Technologies for Distributed Embedded Real-Time Systems

- Task: Create a reliable industrial IoT communication system by utilizing smart contracts, smart arbitration, and smart network management tools.
- Task: Explore the integration of AI in safety critical (autonomous) applications (e.g., driving, robots, manufacturing, drones, …)
- Task: Build a demonstrator platform to evaluate distributed industrial control algorithms based on ARM/X86 processor architectures running real-time Linux.
- Task: Analyze and compare the features of modern industrial & automotive real-time net work technologies (e.g., EtherCAT, Time-Sensitive Networking, TTEthernet, Profinet, Sercos III, …).

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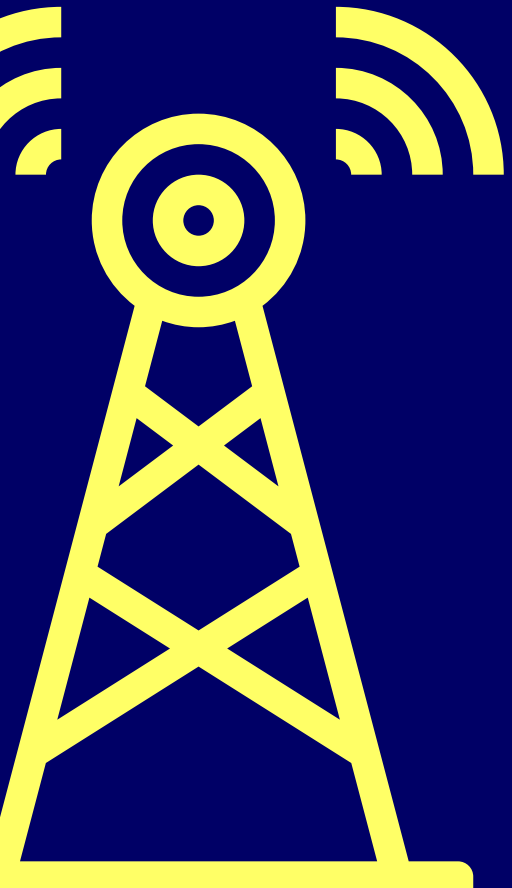

Research Area 2: Risk Assessment and Expert Judgment

- Task: Develop an online platform for assessing and combining expert judgments.
- Task: Create a tool for efficient construction and calculation of risk graphs.
- Task: Analyze and evaluate neural nets and machine learning approaches for calibration of experts.
- Task: Design a robust method for the derivation and refinement of quantitative values from existing qualitative assessments.

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Research Area 3: Methods, Tools & Industrial Informatics Applications

- Task: Help developing the DRIVES platform for future job roles, certification exchange and accreditation in the automotive industry.
- Task: Improve and refine an existing vehicle simulation tool for calculating CO2-emissions for heavy-duty vehicles (VECTO).
- Task: Develop a consolidated (Big) Data Framework and dashboard for the railway industry (GKB).
- Task: Support in designing a Cyber-Security educational program.
- Task: Mining and describing of best-practices and patterns for industrial Cyber-Security, Safety, and Risk Estimation.

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Research Area 4: MacGyver Projects

Invent something extraordinary!

These kinds of topics are not bound to a specific industry project, but can be freely explored in order to do something highly innovative and creative. Either you come up with your own crazy or unusual ideas, or be inspired by some of ours:

- Task: Hack a car, Hack some IoT-device, break an encryption scheme.
- Task: Build a self-driving toy car.
- Task: Do some crazy home automation with IoT.
- Task: Develop an IoT-plant-watering system.
- Task: Applied Machine Learning: Build GAN‘s and let AI‘s fight each other in order to improve themselves. For example: One AI generates fake images of cars, while another detects them with YOLO.
- Task: Create an online platform (Jupyter Notebook) where students can implement some programming exercises (e.g. design patterns).
- Task: Train an AI to calculate risks for cyber security and maybe weight experts based on their earlier prediction accuracy.