University of Stuttgart
Germany
Institute for Control Engineering of Machine Tools
and Manufacturing Units

WE CONTROL THE FUTURE

INNOVATIVELY
INTERDISCIPLINARILY
SCIENTIFICALLY

We are recruiting staff for

HIGH PERFORMANCE AUTOMATION

The Institute for Control Engineering of Machine Tools and Manufacturing Units (ISW) of the University of Stuttgart is one of the leading research institutes in the field of control and drive engineering as well as manufacturing automation.

The ISW provides a workplace with interesting and technically innovative tasks in various areas at the highest international level. Our graduates are now in leading positions of national and international engineering companies.

For graduates of mechatronics or engineering cybernetics and associated disciplines like informatics, mechanical and electrical engineering, ISW provides an excellent environment. As research assistant, you work on challenging projects on your own and within teams, developing new technologies while also fostering your scientific experience, interdisciplinary and creative expertise, and your management skills. Our projects range from fundamental research towards cutting-edge industry-related topics of the day after tomorrow. Ultimately, you are given a unique opportunity to obtain a PhD at one of the most prestigious and worldwide respected institutions in the fied of control and drive technologies.

Did we spark your interest? Then we are looking forward to your application.

Dr.-Ing.
Armin Lechler
Deputy Director
Managing Chief Engineer

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Current job offers can be found under

www.isw.uni-stuttgart.de

Preface

For more than 50 years, ISW has successfully conducted fundamental research activities and challenging industrial projects.

Our core competencies are industrial control engineering and production IT ranging from research and development activities of innovative control approaches and their implementation in embedded and cloud-based solutions. Industrial communication is addressed from the field level with hard real-time requirements up to networks in the cloud. Advances in engineering methods and in simulation keep the increasing complexity manageable.

This brochure gives not only an overview of the research competencies and the teaching curriculum, but also of ISW´s history and its extensive network. At ISW, Industry 4.0 has existed for 50 years!

Consistently high quality publications, proximity to the industry, high-ranking international contacts in both academia and industry, as well as excellent and sustained teaching of our Mechatronics Bachelor and Master students are what marks our strengths.

We are looking forward to future challenges.
Get in touch with us!

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Prof. Dr.-Ing. Alexander Verl

Prof. Dr.-Ing. Oliver Riedel

Milestones

1965
Foundation of the institute on 1 Sept. by Prof. Gottfried Stute

1967-1975
EXAPT, Adaptive Control for 5-axis CNC milling processing

1974-1986
Conception and examination of "Flexible Production Systems" (FFS) and configuration of the first DNC-controlled system

1975-1980
First open modular multiprocessor CNC system (MPST)

1977-1982
Controlled asynchronous drives for machine tool axes

1984-1990
Modular robotics, joints with integrated drive and integrated control

1987-1990
Linear direct drives with digital control based on signal processors

1990-1997
Hardware-independent, modular and open control system (OSACA)

1992-2001
First level parallel kinematics for a CO2 laser processing machine

1994-2001
Acceleration sensors for rotatory and linear movements (Ferraris sensor) for use in highly dynamic drives

1998-2001
Kinematics and control engineering for spatial parallel kinematics

1999-2005
Multimedia machine information system (mumasy)

2000
Founding member and competence center of minimally invasive surgery, MITT

2001
Certification tools and certification authority for SERCOS

2002
Special research area SFB 467: Versatile company structures

since 2002
Adaptronic components for machine tools, adaptive ball screw, oscillation rod

since 2005
TFB 59: Adaptable systems: reconfigurable machines

since 2006
Real-time simulation with VIRTUOS

since 2007
GSaME, Graduate School of Excellence, excellence cluster SimTech

Interdisciplinary research center IZST Stuttgart/Tuebingen

2008
Energy-efficient production through automation – ECOMATION

since 2010
FPGA technology in drive controls

Pendulum for the German Pavilion at the EXPO in Shanghai

since 2012
Control methods for inductive heating

since 2013
Increased dynamics of feed drives via actuator systems

since 2015
Increased productivity in machining with industrial robots

Cable robots for the German pavilion at (the universal exposition) Expo 2015 in Milan, Italy

since 2016
Initiative in the field of time-sensitive networking

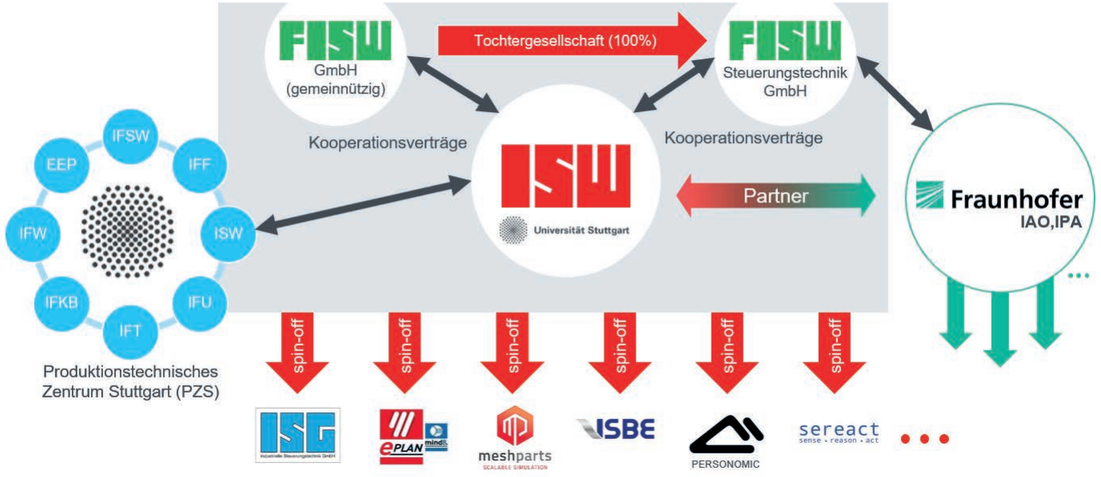
Presentation of the first multi-axis 3D printer at the SPS Drives in Nuremberg

since 2017
International graduate college with New Zealand in the field "Soft Tissue Robotics"

since 2018
Active Member of OPC UA TSN Field Level Communication

since 2019
Cluster of Excellence IntCDC and SimTech

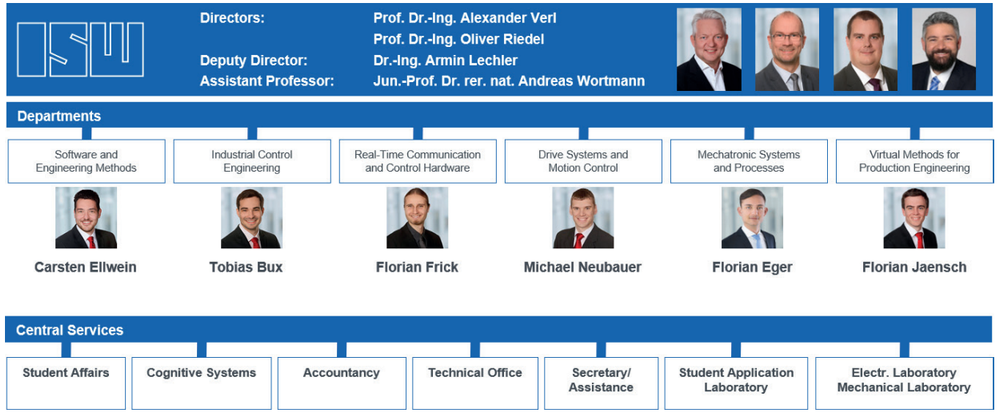
Financing



The ISW is financed for its research work by various research bodies and works in close cooperation with the companies FISW GmbH and FISW Steuerungstechnik Gmbh on industry-oriented developments. Funding necessary for research, technical, and administrative staff are covered by budgetary resources of the university, publicly funded basic research, cooperative industrial research and direct industrial contracts.

Team

In November 2016, Prof. Dr.-Ing. Oliver Riedel redoubled management of the Institute for Control Engineering of Machine Tools and Manufacturing Units together with Prof. Dr.-Ing. Alexander Verl. Dr.-Ing. Armin Lechler continues as Deputy Director of the ISW. Prof. Riedel is holder of the newly established chair **IT for Production** at the University of Stuttgart.



The ISW is subdivided into the following six groups with the focus on:

- Software and Engineering Methods
- Industrial Control Engineering
- Real-Time Communication and Control Hardware
- Drive Systems and Motion Control
- Mechatronic Systems and Processes
- Virtual Methods forProduction Engineering

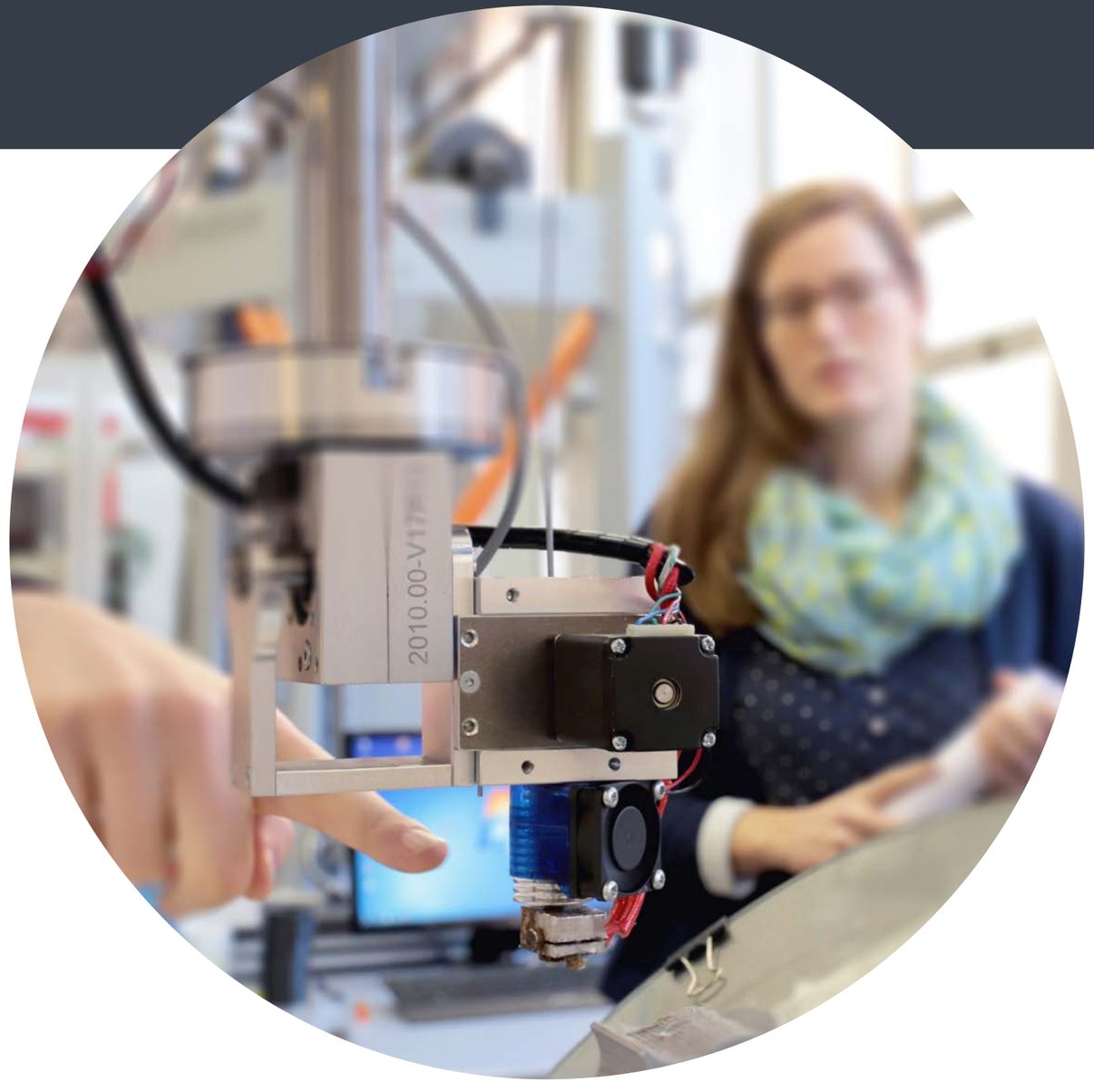
Each group works independently and innovatively on fundamental research and industry-related projects constantly extending state of the art through innovative ideas. Further, the ISW is responsible for the scientific supervision of the Graduate School GSaME for Cluster G at the University of Stuttgart. Central services ensure our success by assuming administrative tasks in student tutoring, organization of teaching and studying, accounting, and secretarial duties. Our technical consulting successfully coordinates our events and marketing activities, while our electrical and mechanical workshops guarantee fast and reliable implementation of test beds, prototypes, and functional patterns.

Teaching at ISW

Integrated within the faculty of "Construction, Production, and Automotive Engineering" (Konstruktions-, Produktions- und Fahrzeugtechnik (Maschinenbau)) of the University of Stuttgart, our research focuses on the conception and application of control technologies for automation of machine tools, robots, and other production facilities. We place special emphasis on the conception and development of planning systems and engineering methods, real-time-capable simulation of production and material flow systems, the design of new, also cloud-based control architectures, and industrial communication, drive, measuring, and control technologies. Being at the edge of current industrial automation technology directly transfers to the lectures we give our students imparting knowledge of control not only related to machine tools and industrial robots.

The ISW works in equal parts on fundamental research and industry-oriented developments, the latter being conducted in close cooperation with industrial partners on national and international level. This allows our students to write their thesis on exciting cutting-edge topics on the pulse. Besides the deep technical knowledge, they acquire valuable qualifications in project handling, scientific work methods and direct contact to industrial enterprises in the field of automation engineering. Numerous opportunities for a successful transition into an industrial career are propelled by direct contact with industrial companies in the field of automation engineering.

Our research findings are subject to practice-oriented testing and validation, the results of which are directly used in our lectures, but also in seminars for experienced engineers.



Working on industrial projects offers our students and research staff possibility to take a peak into industrial companies and allows them to gain first hands-on experiences much like building a life-long lasting network of contacts.

Are you looking for a chance to study abroad? Our international contacts in both academia and industry can provide for great opportunities. We can support you in many different ways to make your stay abroad a successful time.

In our diverse range of lectures, internships, and seminars you will surely find one that suits you perfectly, no matter whether you study machine engineering, mechatronics, technical cybernetics, technology management or medical engineering:

- Control engineering with drive systems
- Control engineering of machine tools and industrial robots
- Applied control engineering in production plants
- Robotic systems – applications in industry and service
- Automation in assembly and handling technology
- Modelling, analysis and design of new robot kinematics
- Planning of robotic systems
- Production Information Technologies
- IT architectures in production
- Control architectures and communication technologies
- Development of scientific software
- Oil hydraulics and pneumatics in control engineering
- Mechatronic systems in medicine
- Bionics

Research

Our interdisciplinary research in technologies for production and automation of the day after tomorrow is always within the focus of industrial applicability. Our research activities include the following key topics.

SOFTWARE AND ENGINEERING METHODS

Driven by the increasing digitalization of the process chain, software, its connectivity and deployment within enterprises gains more and more importance. Especially in areas of industrial manufacturing the borders between shopfloor and office floor become blurred. To take these developments into account the ISW adapts methods, concepts and technologies from the field of software engineering onto control engineering. Service-oriented architectures and containerization are transferred and adapted aiming a flexible production.

Furthermore, ISW does conduct research at model-based and data-driven engineering methods as well as integration of different companies into the manufacturing process under the headline of cloud manufacturing. Research is addressed to industrial processes and attempts to eliminate known deficiencies.

Software methods

- Innovative development and planning methods (simulation-based, functional, modular, etc.) for manufacturing units
- Functional consideration of (IT) safety requirements
- Cloud-based system architectures for automation technology
- Capability-based scheduling of orders

Engineering methods

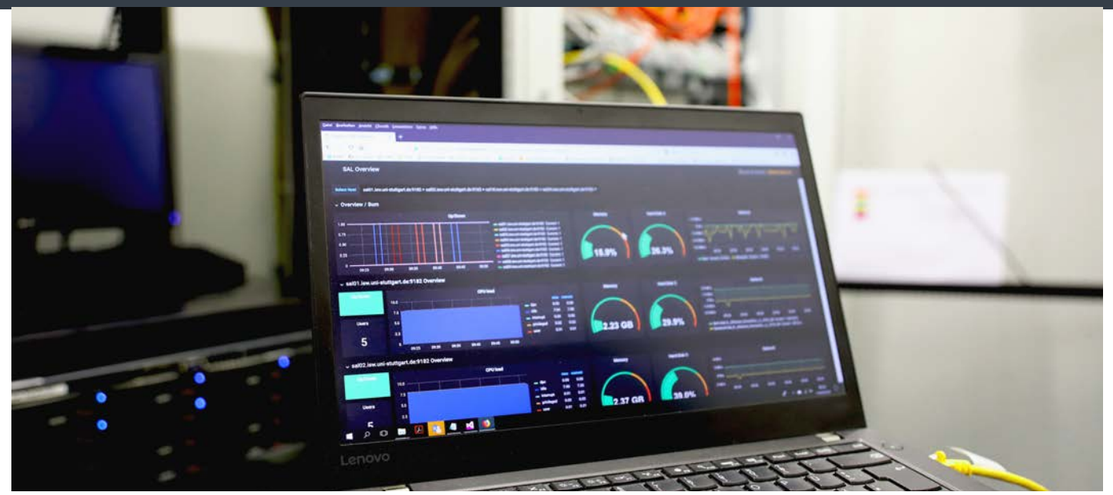
- Model-based process and path planning
- Task and process planning of hybrid manufacturing processes (additive and subtractive)
- Deployment strategies of software for production engineering
- Innovative development and projecting methods (software-based, functional, module-based) for manufacturing units

System analysis and optimization

- Data-driven identification of system (mis)behavior
- Information and system modeling (process planning, data, semantic and communication models)

Projects:

- ARENA2036: versatile production, cell instead of line, new production concepts
- iSrv: intelligent service system, digital production information feedback
- MNC: model-based CNC architecture, automation of casting processes
- ToolProduction: provisioning and transfer of product technology, digital process control
- VFF: training conception



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Research

INDUSTRIAL CONTROL ENGINEERING

Control and drive technology developments in IT. Increasing computing power thanks to Multicore, GPU and FPGA systems, as well as cloud technology, miniaturization of hardware components, and new software concepts are purposefully used at the ISW for the further development of control and drive systems. Among others, the ISW Future developments of control and drive systems are based on our decisive influence on the architecture of current CNC systems, much like our new open drive controller platform, or our testing and certification solutions for field bus and control systems.

Communication technology plays a significant role in machine and plant engineering. Within the initiatives regarding Industry 4.0 and IoT, communication technologies are becoming even more important. In this context, the ISW promotes innovations in the fields of real-time-capable and non-real-time-capable, as well as wired and wireless communication. In addition to the specification of communication protocols, validation and testing are also in the focus of our research. The ISW is firmly established in the Sercos and OPC UA Community.

For many years, the ISW is working in the area of fundamental research concerning algorithms for control engineering in machine tools and plant construction. The objectives are to improve accuracy and surface quality, to reduce the stress on the machine and its tools, and to shorten the lead time. For this purpose, the ISW is developing new interpolation methods and algorithms for collision-free path planning for machine tools, robots, and drive systems. Especially in the field of interpolation methods for CNC systems using clothoids, our team are experts.

In the area of user interfaces, the ISW is examining modular frameworks for development of HMIs and methods of virtual and augmented reality for the use in production. Our driving objective is the generation of value-added services for control of production processes.

Control engineering
- NC core functionality (path planning)
- Manufacturer-specific and comprehensive control interfaces
- Cloud-based control engineering
- Distributed interpolation and decentralized systems

Communication technology
- Standardization, specification, fieldbus certification
- LTE-based and TSN-based communication
- OPC UA

User interface
- VR/AR-based user interaction in production

Projects:
- Devekos: distributed interpolation and control for multi-component systems
- CLM4.0: Closed Loop Manufacturing 4.0 with real-time process control on a smart-box

- Cornuspline 2: G2-continuous smoothing algorithm for CNC controls with piecewise defined clothoids
- FabOS: vision for an open, distributes, real-time capable and secure operating system for production
- KaBa: camera-based path planning for industrial robots
- KOSMoS: collaborative smart contracting platform for digital value-adding networks using blockchain technology
- RetroNet: networking of machines and plants in the cloud and service platform
- SeRoNet: service-oriented backend for service robot solutions
- SmartCNC: development of a SmartCNC system for integration of the CAM system into the CNC control system
- SmartFTF: development of adaptive path planning for the consideration and bypassing of static and for the first time dynamic objects/obstacles

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Research

REAL-TIME COMMUNICATION AND CONTROL HARDWARE

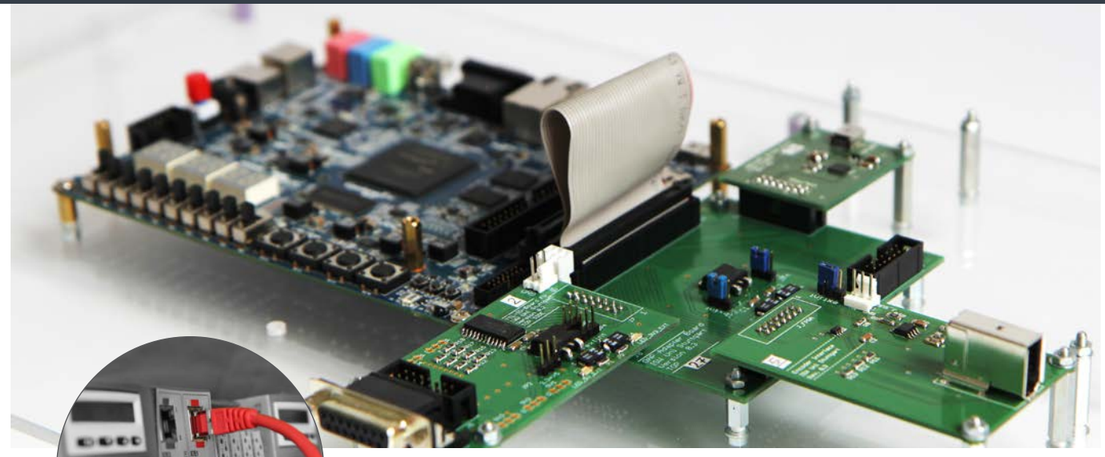
Real-time communication has always been a key technology in any production system. To enable the digitalization of production, operation technology (OT) is now being integrated with information technology (IT). The focus of research is shifting towards interoperable converged communication systems including wired and wireless technologies, while still supporting traditional field-buses. Emerging technologies such as TSN and OPC UA are used alongside Sercos, EtherCAT, and sensor data protocols.

Control systems have an ever increasing need for computational performance. The development of IIoT creates a demand for customized hardware platforms. In research, standard platforms often do not fulfill the requirements regarding performance, flexibility and interfaces. Therefore, besides using existing platforms, own hardware platforms are developed utilizing multi-core architectures, GPUs and FPGAs but also designing PCBs and power electronics. Key aspects are hardware-software codesign including the engineering process, resulting in developments like our FPGA-based Open Automation Platform (OAP). Applications are drive control systems, hardware accelerated simulation engines, drive and process control systems, and innovative sensor solutions.

Real-time communication
- Time-sensitive networking (TSN)
- Fieldbuses
- Wireless communication
- Open source stacks
- Hardware implementations

Control hardware & architectural concepts
- CPU and embedded platforms
- Open control platforms
- Application of FPGA technology
- Recording and processing of sensor data
- Control concepts for servo drives and special applications
- Power electronics and converter technology

Projects:
- Adaptive PWM: improving the energy efficiency of drives through dynamic switching frequency of the power electronics
- AccessTSN: modular open source driver for real-time applications within a TSN based network
- EDK: evaluation of wireless technologies for industrial real-time communication
- MF-Thixo: continuous measurement of the microstructural condition during inductive heating of components for thixo forging
- Open Automation Platform (OAP): flexible and FPGA-based real-time platform with open interfaces
- RoboSkin: hardware-accelerated sensor-data-fusion and communication platform for printed surface sensors for robotics
- TSN4Automation: support for getting started with real-time Ethernet for automation companies
- TSN4KMU: modular TSN router platform with customizable hardware accelerators
- TSN Testbed: interoperability Testbed for TSN devices with regular Plugfests and permanent installations



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Research

DRIVE SYSTEMS AND MOTION CONTROL

Dynamic behavior of machines and robots determines quality and cost of manufactured products. The overall behavior results from the coupled interaction between mechanical components and controlled drive systems. In order to meet the ever increasing requirements of machinery and plant engineering, the ISW is researching motion control and machine technology.

In the field of motion control, a major challenge is the precise and dynamic adjustment of position and speed of movable machine components. Basic requirements for controlled electromechanical drive systems are effective trajectory tracking control along with the compensation of disturbances. In order to achieve higher accuracies and dynamics for linear and rotary drive systems, novel control and compensation methods are being researched.

In the field of machine technology, the ISW is researching innovative feed drive concepts and further developments of common drive systems (ball screws, rack and pinion drives, direct drives). This includes dimensioning, assembly, commissioning, and accompanying FE simulations as well as experimental investigations.

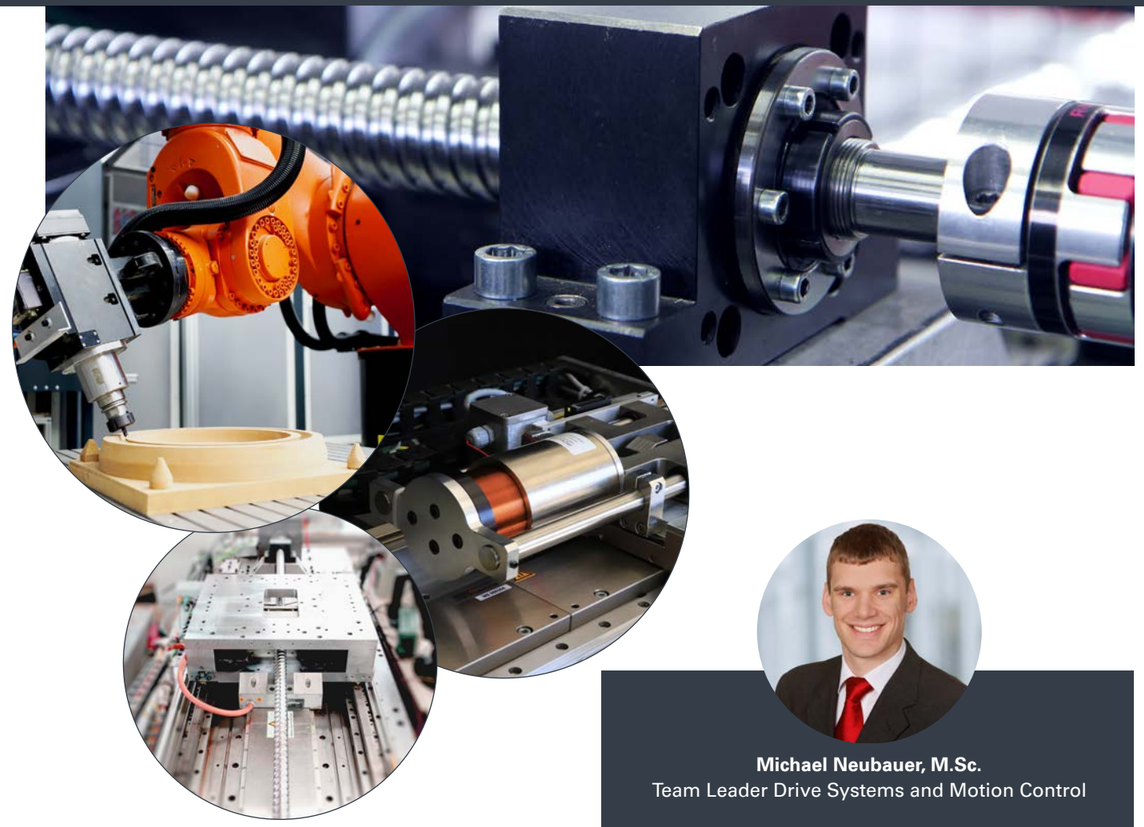
We have a wide range of test stands with different drive systems as well as various machines and industrial robots. This allows a variety of experimental investigations and an application-oriented validation of novel approaches. In addition, we have parameterized dynamic models of common drive systems and industrial robots for the time-efficient investigation of developed methods and concepts.

Motion control
- System dynamics of controlled drive systems
- Novel and advanced control structures
- Compensation methods

Machine technology
- (Novel) feed drive systems
- Optimization of drive system components

Industrial robotics
- Model-based control systems
- Machining Tasks

Projects:
- IMPULS: impact-based feed drive actuator for improved path guidance
- KUMS 2: backlash compensation for rack and pinion drives based on acceleration measurement of the machine table
- SDaR: drive-based vibration damping on industrial robots for machining
- SiRoWo: automation of robot-based machining tasks for wood and composite materials
- Soft Tissue Robotics: model-based control of robots interacting with soft materials
- TopGen 2: applied topology optimization for additive manufacturing of machine components



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Research

MECHATRONIC SYSTEMS AND PROCESSES

We look at machines and production facilities, considering them as mechatronic systems. Our research improves process reliability, increases efficiency and allows new technologies to be transferred into the industry.

Mechatronic systems can be found in every manufacturing environment, be it sensors, drives or robots; even the production facility in its entirety can be considered a mechatronic system. We dive into the challenges of such highly inter-connected systems and bring new control algorithms to the table. Not only are we able to improve accuracy of CNC milling machines by adaptive preloading, we also reduce scrap and rework in multi-stage production systems through modern analytical solutions.

Our expertise in modeling and controlling from a single component up to the full system reflects well in our advanced additive manufacturing. We consider the process as a whole i.e., from the CAD file to the final product. Beside the competence in new multi-axis kinematics for 3D printing we also develop process oriented offline path planning strategies, online feed-forward and closed-loop control with high frequent real-time simulation.

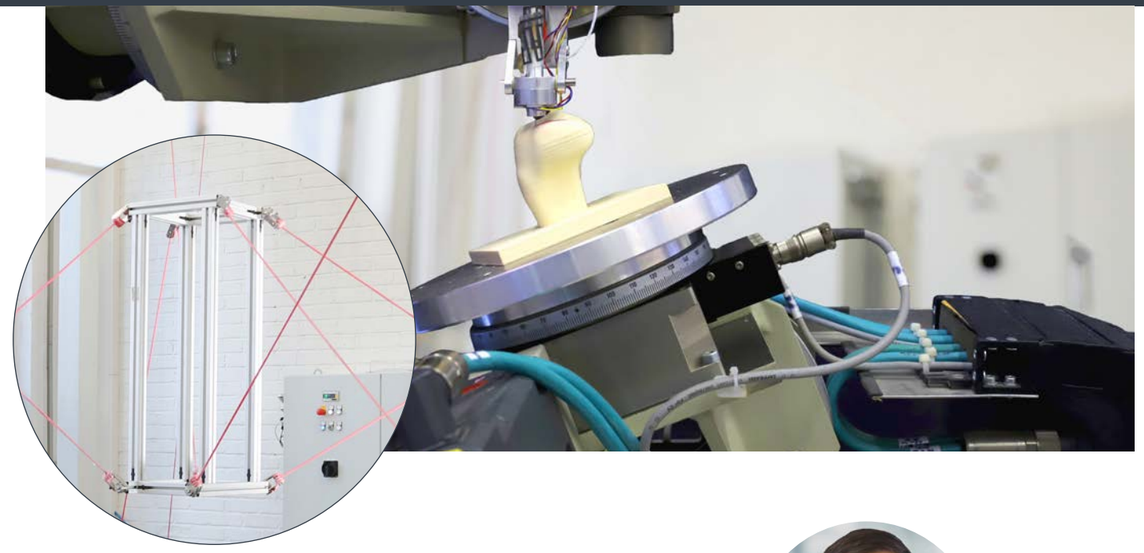
Cable-driven parallel robots will gain momentum as they combine advantages of serial and parallel robots: large workspace, high payload, and high dynamics. We research the elasto-dynamics and closed-loop control of cable robots, as well as how to have them reconfigurable to changing requirements. With our tools for designing cable robots, we develop systems with endless rotation for handling tasks and design devices for additive manufacturing.

Dynamics of mechatronic systems
- Modeling, simulation and system identification
- Optimization of single and multi-stage systems

Additive manufacturing
- Free-form printing from CAD file to product
- Development of high-frequency control procedures

Cable robots
- Elasto-dynamics modeling and control
- Reconfiguration and new kinematic structures

Projects:
- Biological Design and Integrative Structures: additive manufacturing of bionic components with composites
- Cable Robot Simulation: elasto-dynamics modeling of cable-driven parallel robots
- CLM4.0: Closed Loop Manufacturing 4.0 with real-time process control on a smart-box
- EndlessZ: parallel robot with endless rotation using only cables
- ForZDM: reduction of scrap in multi-stage production systems via downstream compensation
- High Performance Center "Mass Personalization": joint initiative investigating procedures and business models for mass-production of personalized products
- Rack and Pinion Drive Systems: increasing efficiency by adaptive preloading during operation
- SeilStrgConf: in-service reconfiguration of parallel cable robots to adjust for changing environments
- Soft Tissue Robotics: closed-loop control of industrial robots for handling of soft materials



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Research

VIRTUAL METHODS IN PRODUCTION ENGINEERING

The ISW is developing technologies for digital engineering for the day after tomorrow. In the life cycle of machines and plants, there is need for innovative digital models, methods, and tools that make the increasing complexity of future production systems manageable, enable optimization, and even virtual factory acceptance tests using a comprehensive virtual image of production, and support production during operation. With scientific developments in the field of real-time simulation for virtual commissioning, the ISW is one of the leading research institutions in the field of virtual production.

Virtual commissioning

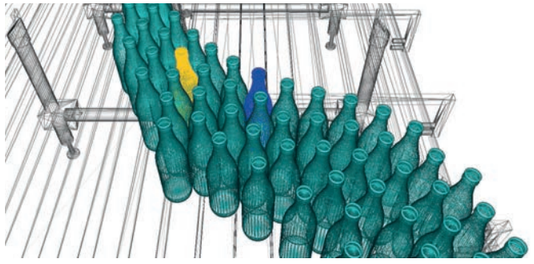
- Model-in-the-Loop, Software-in-the-Loop and Hardware-in-the-Loop simulation
- Integration of virtual commissioning into engineering (e.g. by automatic generation of digital twins)

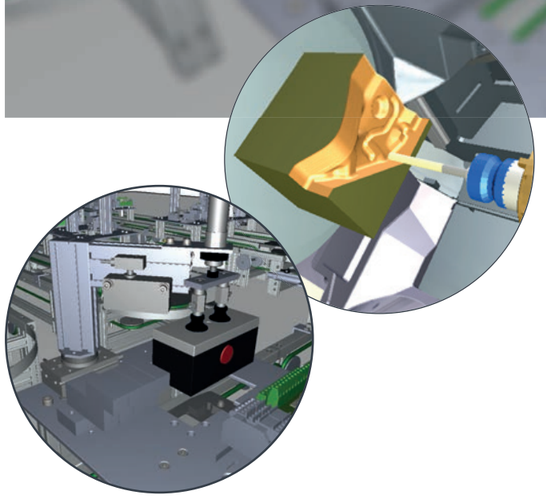
Digital factory

- Simulation-based development, system planning, testing, training, service and operation of production plants and processes based on coordinated digital methods and tools
- Integration of innovative simulation-based methods and tools into the engineering of machine and plant manufacturers
- Process, machine and plant simulation in different real-time levels and scales
- Co-simulation of complex production plants on standard PCs up to high-performance computers
- Computational intelligence based on model-based digital twins

Projects:

- CoSBE: continuous simulation-based engineering Platform
- Digital Twin: automated engineering of fully automated assembly lines
- Online Change: online change and snapshot for HIL simulators
- OptiPlant: combined optimization and virtual commissioning of material flow-intensive production systems with multiscale network models
- Soft Tissue Robotics: machine learning for handling operations of soft materials
- Virtual bin picking: sensor simulation and deep learning for pose recognition and pose prediction
- Virtual control test bench: advanced virtual commission through test automation
- Virtual tabletop soccer: student competition at the HIL Simulator





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Virtual Methods in Production Engineering

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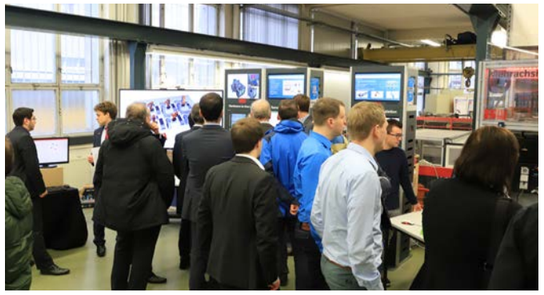
Services for the Industry

The ISW advises companies on research topics dealt with at the institute and thus helps to ensure the knowledge transfer from fundamental research to the industry. Moreover, companies are supported in the implementation from prototypes to new products according to their requirements.

Consulting and development:

- Control concepts, architectures and algorithms
- Communication technologies (OPC UA, sercos, ProfiNet, EtherCat, TSN)
- Special purpose machines
- Modeling and simulation
- Modularized engineering
- FPGA solutions
- Optimization of machines and components
- Design of drives
- Software architecture
- Technology consulting
- Design and parametrization of closed-loop control systems
- Additive manufacturing
- Analysis of positioning accuracy of drive systems
- Security analysis of controls



Training and seminars:

- Stuttgart Innovation Days
- Stuttgart Production Academy
- Industrial Working Group Simulation Technology
- Ethernet-based communication (OPC UA in control and automation engineering)
- Industry Working Group "TSN for Automation"
- Hardware-in-the-Loop simulation
- IIC-TSN-Testbed Plugfest

Dr.-Ing. Armin Lechler
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Stuttgart Innovation Days

As part of our event series "Stuttgart Innovation Days – Control Technology from the Cloud", today's possibilities and solutions are subjected to a reality check. It serves as an interface and networking platform between research and industry and is intended to promote the exchange and inspiration of interdisciplinary solutions and ideas.

Stuttgart Innovation Days 2018 at the Riding Hall, Maritim Hotel Stuttgart

Industry Working Group "TSN for Automation"

With the foundation of an application-focused interest group covering the whole field of industrial production, we intend to define the future application of real-time ethernet in automation. We evaluate technologies in practical environment while also sticking to proven concepts from the state of technology. Of course, in the sense of technology leadership, this has to be done sooner than later. Our activities are interdisciplinary and cover different vendors and industries – focused on production engineering and industrial automation. Further information can be found at: **www.tsn4automation.com**

Opening event "TSN for Automation" at the ISW

IIC-TSN-TESTBED

Thanks to interoperability between devices from different manufacturers Time-sensitive Networking (TSN) has gained wide recognition by the industry as an enabling technology for the production of the future. To avoid coterminous development and varying interpretation of standards, as well as for enabling testing at an early stage, the Industrial Internet Consortium IIC's test bed is hosted and supported fully by ISW. Further information can be found at: **www.iiconsortium.org/time-sensitive-networks.htm**

IIC TSN Testbed Plugfest 2018 at the ISW

Fairs and Exhibitions

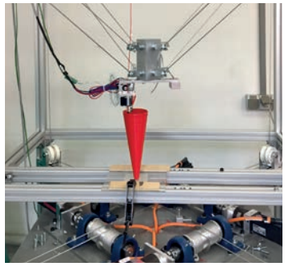
SPS IPC DRIVES

HANNOVER MESSE

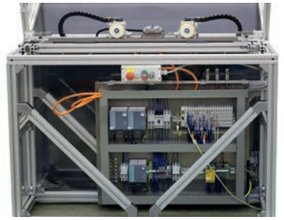
The institute presented its latest research topics at SPS IPC Drives 2018 in Nuremberg:

Industrial communication with TSN and OPC UA

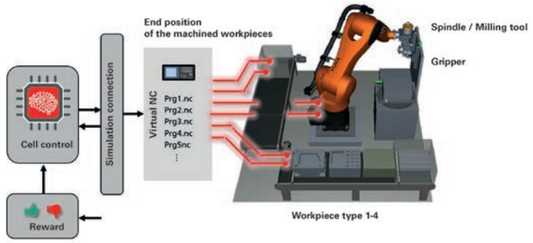
Real-time capable integration platform for virtual commissioning



Cable-driven 3D printer

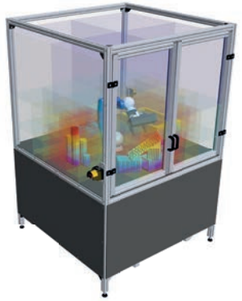


Adaptively braced rack and pinion drive system



Machine learning of control logic using a digital twin

Cloud-based robot welding

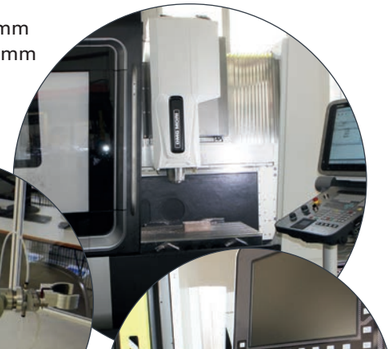


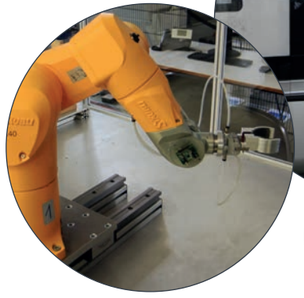
Camera-based path planning for industrial robots

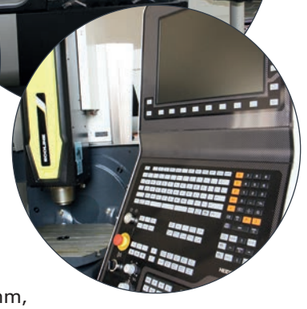
Machinery

ISW scores with versatile machinery

Machine tools:
- **Maho MH800E**, CNC milling machine, workspace: X800 Y450 Z500 mm
- **DMG DMC 650V,** workspace: X650 Y520 Z475 mm
- **DMG DMU 50 ecoMill**, 5-axis CNC milling machine, workspace: X500 Y450 Z400 mm
- **Exeron Digma HSC600**, 5-axis CNC milling machine, workspace: X650 Y550 Z400 mm
- **Hermle UWF**, 3-axis CNC milling machine, workspace: X850 Y630 Z500 mm
- **7-axis CNC** "Model Milling Machine"
- **Deckel FP3A**, universal milling machine, workspace: X500 Y300 Z400 mm







Robots:
- **Kuka KR210**
- **Stäubli TX40**, 2 robots
- **Franka Emika** Panda
- 7-axis **KUKA KR500** robotic processing cell
- Spatial **cable robot** COPacabana

Workshop machines:
- Band saws
- Bench drills
- Box column drills
- Bench grinders
- Turning machine Weiler Praktikant140, center height 140 mm, center distance 650 mm
- Turning machine VDF, center height 230 mm, center distance 1000 mm
- Horizontal surface grinding machine Blohm, grinding length 700 mm, grinding width 350 mm, grinding height 425 mm

Other equipment:
- Test stand "Ball screw drive"
- Test stand "Rack and pinion drive"
- Test stand "Small machine tool"
- Test stand "multi-axis demonstrator for distributed interpolation"
- Linapod parallel kinematic as 3D printer
- Test facilities for additive manufacturing (various axle configurations)
- Control laboratory
- Drive laboratory
- Student application laboratory

Contact

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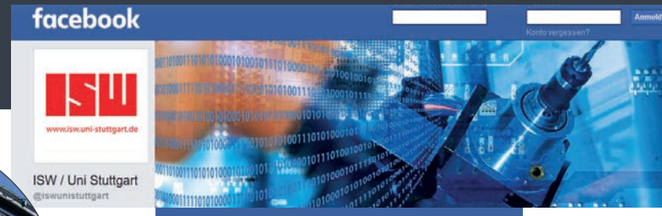

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TRAVEL DIRECTIONS

By car:
From direction Munich or Karlsruhe A8, take exit 52b (Stuttgart-Degerloch). Follow B27 towards Stuttgart-Zentrum. From Charlottenplatz, continue driving on Schlossstrasse towards Berliner Platz, then turn right onto Seidenstrasse.

Public transportation:
At **Stuttgart main station** (Stuttgart-Hauptbahnhof, Hbf) take bus 42 (direction Erwin-Schoettle-Platz) and alight at Rosenberg-/Seidenstrasse. From Rotebühlplatz/Stadtmitte take tram U4 (direction Hölderlinplatz) or bus 43 (direction Killesberg) and alight at Rosenberg-/Seidenstrasse.

From **Stuttgart Airport** (Flughafen/Messe) take the subway S2 (direction Schorndorf) or S3 (direction Backnang). Alight at Rotebühlplatz/Stadtmitte, and continue by tram U4 (direction Hölderlinplatz) or bus 43 (direction Killesberg) and alight at Rosenberg-/Seidenstrasse.

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