GOSTOP

GOSTOP Program

BUILDING BLOCKS, TOOLS AND SYSTEMS FOR FACTORIES OF THE FUTURE

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FOR FACTORIES OF THE FUTURE

Ljubljana, Slovenia, 2020

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PREFACE

In front of you is a brochure that presents the final results of the largest program to date in the field of Factories of the Future in Slovenia. The program "Building blocks, tools and systems for the factories of the future - GOSTOP" was funded by the European Union, the European Regional Development Fund, the Republic of Slovenia, the Ministry of Education, Science and Sport (MIZŠ) and Slovenian industry. It is an excellent example of good practice in connecting R&D organizations and the industry at the technological readiness level of TRL 3-6.

One of the key achievements of the GOSTOP program is the parallel emergence of many new research groups, especially in the industrial environment. These groups, together with research partners, successfully acquired new domestic and international projects with additional financial investments. In this way, additional resources were created, which further accelerated investments in research and development projects and enabled additional transfer of knowledge and achievements of the program to the field of research and industrial commercialisation. With this program we established and supported an innovative environment in Slovenia among recognisable actors, thus creating an intertwining of key enabling technologies (horizontal knowledge networks), with vertical value chains (with associated markets) in the field of factories of the future, which is summarised in the quote by the international evaluator on the right-hand page. We should also mention that the

areas of connections with horizontal networks of nanotechnology, plasma technology and modern production technologies for materials have so far been neglected and thus disadvantaged due to limited funds in the state call under S4 (TRL 3-6). Therefore, we expect that these areas will be properly included in the next perspective.

For top products or services we need top research competencies, capacities and significant investments, which (an example of the experience of the GOSTOP program) urgently need to be supported by the state with an emphasis on continuity, which is greatly lacking. Of course, the success of such programs requires an excellent foundation in basic research (TRL 1-3) with associated modern research equipment. As a logical continuation of the program, activities in the form of commercialisation projects (TRL 6-9) should follow in a coordinated manner. Therefore, the program is vigilantly monitoring and supporting the Strategic Research and Innovation Partnership (SRIP) Factories of the Future (FoF). The experience and results of the GOSTOP program will undoubtedly contribute positively to the further implementation of activities within the SRIP FoF in the direction of continuing the S4 program, as well as to further the transformation and penetration of the Slovenian industry with new products, services and technologies into the field of factories of the future.

With the brochure we want to present the results to the general professional public and thus encourage further commercial and research connections with all actors, both domestically and internationally. With this we want to upgrade the story of the GOSTOP program wherever there are opportunities and needs to continue or establish new connections, activities and interweaving in the future.

Ass. Prof. Dr. Igor Kovač
Coordinator of the
GOSTOP Program,
Jožef Stefan Institute

Jožef Stefan Institute
Ljubljana, Slovenia
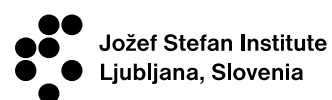
Summary of the international evaluator

Congratulations to the co-ordinator and the whole GOSTOP staff for the achieved, excellently presented performance! The final recommendation can only be: continue in this fashion, and try to further improve the information of the public opinion, how well the taxpayers' money is spent for the benefit of society. In order to spread the elaborated technology to even smaller industries, a turn-key pilot line and a company has to be set up with governmental support to market the own Slovenian knowledge obtained a.o. by GOSTOP. This is what the stakeholders lead by the excellent coordinator are asking for and expecting together with the evaluator.

Vir: www.gov.si/assets/ministrstva/MIZS/Dokumenti/ZNANOST/Strukturci/GOSTOP-Report.pdf

REPUBLIC OF SLOVENIA
MINISTRY OF EDUCATION,
SCIENCE AND SPORT

EUROPEAN UNION
EUROPEAN REGIONAL
DEVELOPMENT FUND

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MINISTRY OF EDUCATION,
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DEVELOPMENT FUND

GOSTOP Program

The three-and-a-half-year program, starting in November 2016, involved nineteen partners from thirteen Slovenian companies and six research organizations, listed in the table below. They participated in a multitude of intertwined projects. The total value of the program was nearly EUR 9.4 million. The program was coordinated by Jožef Stefan Institute.

Taking into account the Slovenian Smart Specialization Strategy - S4 and the strategy of developing the concept of smart factories, we carried out activities by pillars in the areas of control technologies, tooling, robotics and photonics, as is shown in the figure on the right-hand page, which illustrates the structure of the program with the content activities. These are the areas in which Slovenia has increased and upgraded its existing knowledge, capacities, competencies and innovation potential with the GOSTOP program, thus strengthening its visibility and positioning on global markets.

TYPE OF PARTNER	NAME OF PARTNER ORGANIZATION
RESEARCH & DEVELOPMENT PARTNERS	Jožef Stefan Institute (coordinator)
	University of Ljubljana, Faculty of Electrical Engineering
	University of Ljubljana, Faculty of Mechanical Engineering
	University of Ljubljana, Faculty of Computer and Information Science
	University of Maribor, Faculty of Electrical Engineering and Computer Science
	TECOS - Slovenian Tool and Die Development Centre
COMPANIES	Kolektor Group
	INEA
	METRONIK
	HIDRIA ROTOMATIKA
	YASKAWA Slovenija
	PODKRIŽNIK
	NELA razvojni center
	COSYLAB
	L-TEK
	ŠPICA INTERNATIONAL
	OPTOTEK
	LPKF
	FOTONA
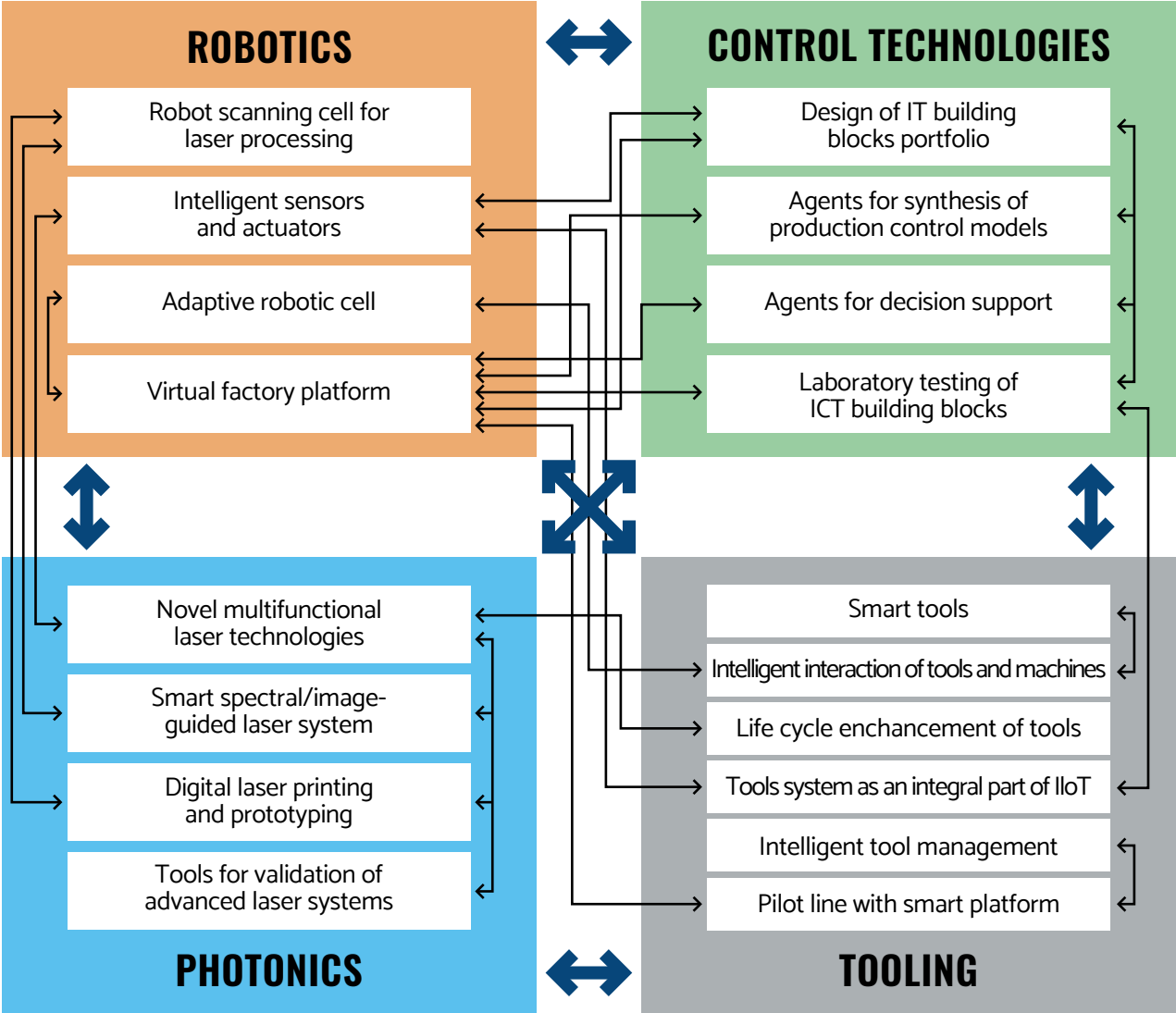
RESULTS

Key results of the program are presented in the brochure by individual pillars. A total of 38 technological achievements are presented, which fully reflect the framework of the set goals from the previously prepared proposal. The results are carried out in accordance with the program according to the required technological stages. The success of the transfer of new knowledge from the research environment to industrial practice is presented, as well as the illustrated effect we expect from the following phase of commercialisation. In some activities, the required demonstration or prototype phase was even exceeded, as the companies independently accelerated the commercialisation phase according to the needs of the market.

The results of the program were intentionally presented in a commercial way with a commercial title.

Following a brief general description, the purpose, function, innovation, effects and areas of application of each result are described. The results of the program are the product of the work of several contributing partners, which are also listed. At the end of each presented result there is contact information you can use to learn even more about the project.

The presented technological achievements are central but not the only result of the GOSTOP program. In order for these results to be created and to come to realisation in the future as products or services on the market, a number of accompanying activities were needed, which resulted in additional achievements. Some of the most interesting ones are shown in the picture on the right-hand page.

17
Patents

40
Innovations

48
Publications in journals, at conferences, workshops, panels

225
Implemented marketing and promotional actions

96
Organization of conferences, workshops, panels

62
New project proposals (domestic and international)

CONTROL
TECHNOLOGIES

A PLATFORM FOR MULTIAGENT CONTROL BASED ON IIoT SENSORS

A multiagent system for distributed control, that uses smart sensors and actuators, ensures a greater robustness and resilience to disturbances of industrial IIoT systems. The distributed control is demonstrated on a case of an industrial compressed air system, controlled by intelligent IIoT sensors and valves.

Purpose

The pressure control in industrial compressed air systems with several consumers and suppliers of compressed air is usually implemented by applying the simple bang-bang control. The developed multiagent system will enable a more precise distributed control and thus the optimisation of the performance of the entire system.

Function

The developed control system enables the control functions of the actuators to be adapted to the topology of the compressed air pipeline network, which improves the resilience and robustness against malfunctions.

Innovation

The developed multiagent control system is easy to implement, adaptable to changes in the system configuration and is able to react quickly to disturbances. At the same time, it improves the performance of the system compared to the commonly used bang-bang control. To achieve adaptability, the newly-developed system uses reinforcement learning methods, which allow the system to be optimised simultaneously with the operation of the system in real life or in a simulation without the need to manually change the control function settings.

Effects

Compared to the common control approaches, the developed software agents for industrial compressed

air system control improve the robustness of the control in case of disturbances and enable a faster adaptation to changes in the system configuration and to changing conditions.
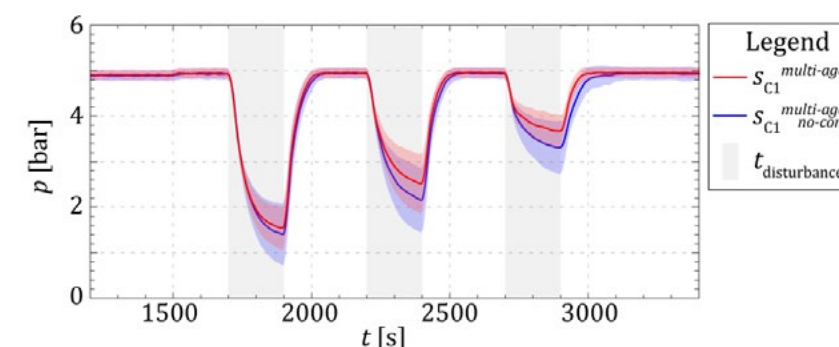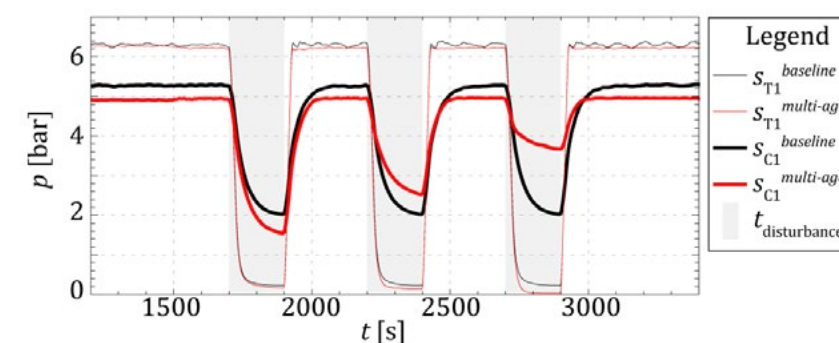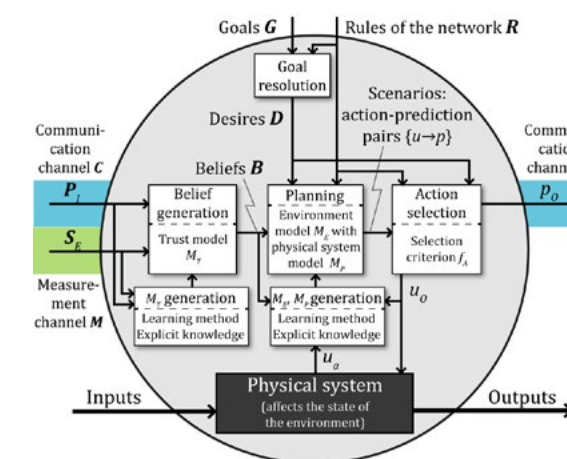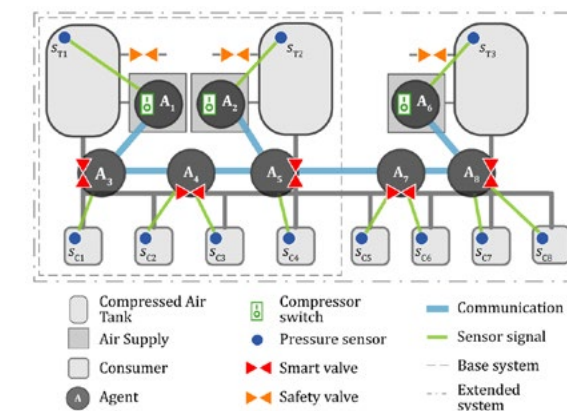
Areas of Application

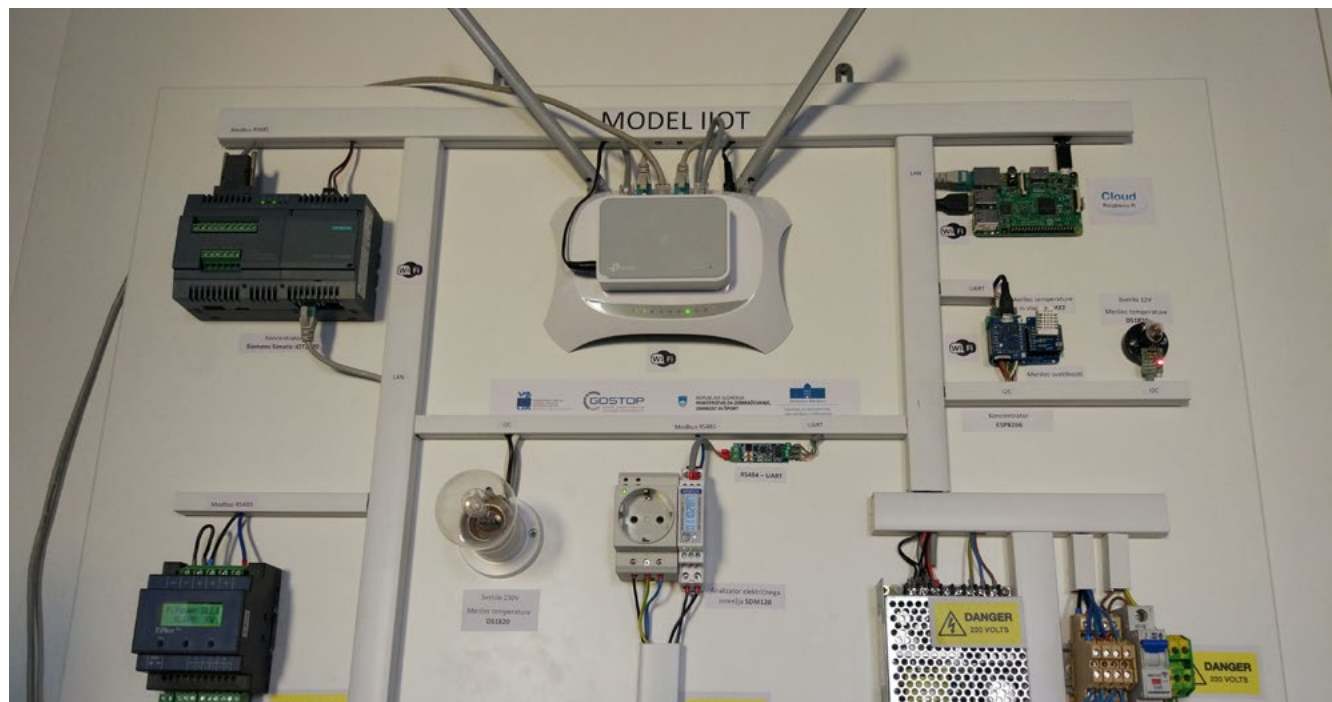Industrial control systems using IIoT; Control of industrial compressed air systems.

Contributing Partners

- L-Tek d.o.o. (www.l-tek.com)
- University of Ljubljana, Faculty of Mechanical Engineering, LAKOS (fs.uni-lj.si)

More Information

- Matej Slapšak (matej.slapsak@l-tek.com)
- Rok Vrabič (rok.vrabic@fs.uni-lj.si)

COMMUNICATION AGENT FOR DATA TRANSMISSION IN SPATIALLY DISTRIBUTED SYSTEMS

The communication agent collects and sends data from remote data sources to the process (Big Data) historian in order to visualise and analyse data in a web and mobile environment.

Purpose

The purpose of the communication agent is to collect process data from energy and utility facilities, manufacturing plants and other processes. The collected data can be used within:
· Advanced analytical tools for alarming and notification
· Energy accounting
· Analysis of energy flows in buildings using advanced analytical tools
· Energy saving

As part of the project we designed a demonstration model for testing telemetry devices and IIoT systems. The model allows remote access to laboratory processes, the implementation of exercises and experiments and the testing of new technologies.

We have developed and tested the following telemetry devices that are based on different platforms:
· Raspberry Pi
· SIEMENS SIMATIC IOT2040
· GEMALTO EHS6T

Function

The developed communication agents enable:
· Collection and transfer of process data from edge locations to a central process historian, which is suitable for use in "Big Data" systems or cloud services
· Collection of data from measuring devices (energy system) connected to the MBUS (or Modbus) bus
· Sending data to the historian data centre using different communication technologies with minimal bandwidth usage
· Storing and forwarding mechanism (in case the data centre is unavailable, the communication agent stores and buffers the measurements locally. When the connection is restored, the archived data is automatically transferred to the data centre (with the original time stamp) and deleted from the local archive)
· Secure data transmission

Innovation

The system is open, flexible and price affordable. It enables the implementation of different communication protocols.

Effects

Within the project, the developed modules (GEMALTO) were used in a real project (energy facility) for the purpose of collecting and sending the process data to a process historian data centre in Metronik company's (local) cloud. The process data can also be visualised and displayed in a web environment.

The developed modules are in use and in the sales offer of Metronik d.o.o.
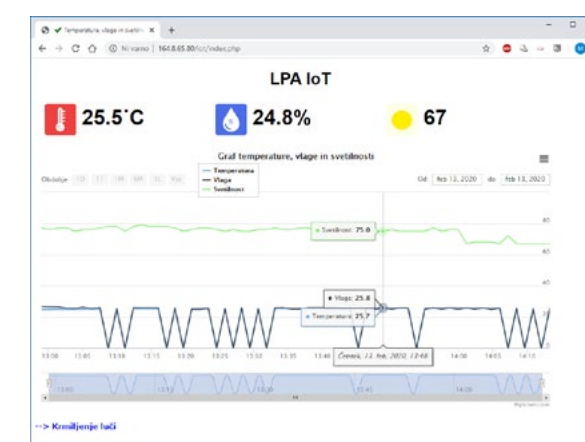
Areas of Application

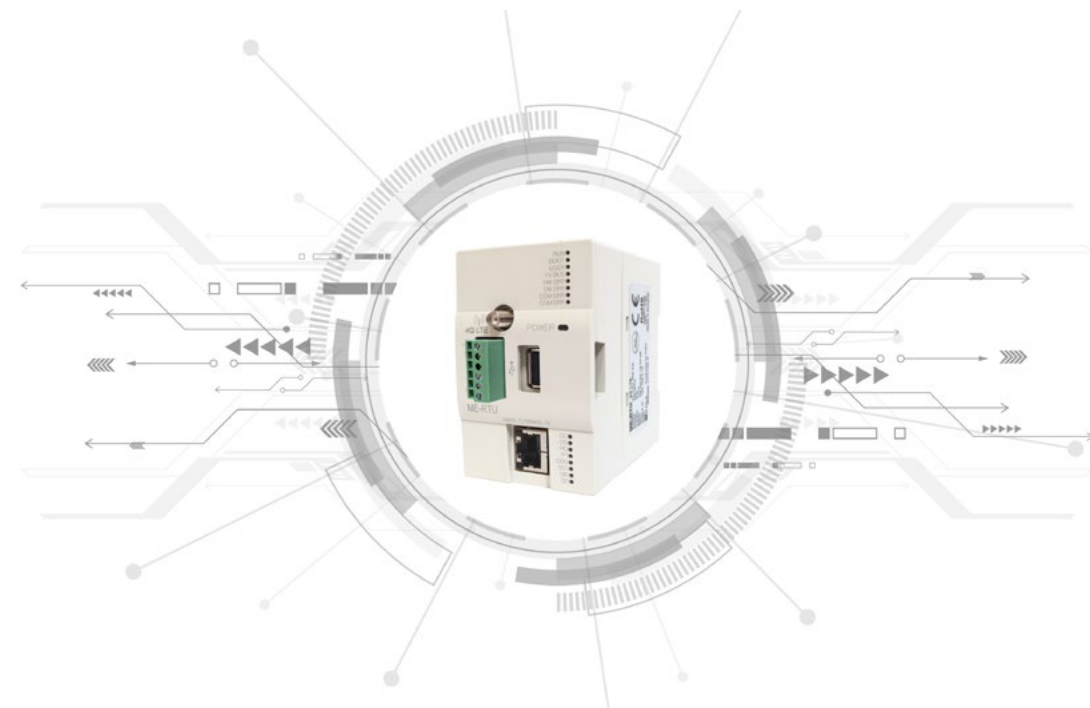Infrastructure facilities, buildings and industry.

Contributing Partners

· Metronik d.o.o. (www.metronik.si)
· University of Maribor, Faculty of Electrical Engineering and Computer Science, Laboratory for Process Automation (au.feri.um.si/lpa)

More Information

· Aljaž Stare (aljaz.stare@metronik.si)

ME-RTU

LTE network Remote Telemetry Unit.

Purpose

Remote system control and data acquisition with a poor communication infrastructure are in need of new communication routes. A mobile network offers good coverage in urban as well as rural areas. In order to connect devices from different manufacturers, standardized communication protocols are needed. The communication route must be encrypted to prevent the abuse of data by potential hackers.

Function

The unit has a built-in 4G LTE modem that provides a communication link between the control center and the remote system. A radio modem can also be connected to the USB port and furthermore, the protocols enable connectivity between devices and systems from different manufacturers.

Innovation

The unit combines the functions of different devices, such as RTU unit, GSM modem and industrial controller communication module. When transferring data, the information is protected from possible attacks. The unit can be powered by photovoltaic cells or a wind turbine as it has a low power consumption.

Effects

10% less energy consumption due to a more effective control, 15% less congestion on remote devices, and a 20% reduction in management costs because of the remote control.

Areas of Application

Control and management of remote systems: water supply, gas pipelines, power stations, switching stations, road tunnels and wastewater treatment plants.

Contributing Partners

- INEA d.o.o. (www.inea.si)
- Jožef Stefan Institute (www.ijs.si)
- University of Maribor, Faculty of Electrical Engineering and Computer Science (feri.um.si)

More Information

- INEA d.o.o. (info@inea.si)

FUNCTION	SPECIFICATION	SUPPLEMENTARY INFORMATION
COMMUNICATION CHANNELS	Cellular network: LTE, UMTS/HSPA+ and GSM/GPRS/EDGE	• Via built-in cellular transmitter/receiver • SMA antenna connector • User-provided SIM Card with data contract / APN from local cellular network provider
	Ethernet (10/100 Mbps)	RJ45 connector to, for example, corporate WAN (IEE 802.3), xDSL (ITU G.992.x) or PLC (Power Line Communication) WAN (IEEE 1901)
	Serial	Via USB port plus USB / serial converter to an external Radio, PSTN or satellite modem
COMMUNICATION PROTOCOLS (HOST-SIDE)	DNP3 (IEEE 1815) IEC 60870-5-101 IEC 60870-5-104	Yes (Level 2 Slave) Yes (Slave) Yes (Slave)
COMMUNICATION PROTOCOLS (FIELD-SIDE)	IEC 60870-5-104 IEC 61850	Gateway multi master, single slave Gateway multi-client, single slave IEC 6087-5-104
TIME SYNCHRONISATION	SNTP / NTP (or from DNP3 / IEC 60870-5 protocol)	Selectable from suitable (S)NTP server (GPS, GLONASS, Radio clock sourced) or via the DNP3 or IEC 60870 protocols
STORE AND FORWARD	Yes	• RTU samples and stores data locally when communication channel to SCADA host is interrupted and transmits this stored data when channel is restored • User configurable store and forward buffer size

DIAGNOSTIC SYSTEMS FOR END-OF-LINE QUALITY ASSESSMENT OF ELECTRIC MOTORS

The developed systems provide complete end-of-line quality control of electric motors for vacuum cleaners and washing machines.

Purpose

With an increasing global competition and the demand for 100% quality the diagnostic systems for end-of-line product quality control are becoming a necessity in every production process.

In recent years, companies have been upgrading production lines with the ability to flexibly produce different electric motors and quickly switch between them. The end-of-line quality control diagnostic system must follow this trend and allow for such flexibility, both in terms of the test itself, as well as the classification of results and evaluation with specific limit values.

Function

The diagnostics of various electric motors, a simple change of product type, the programming of test and operating parameters.

The main function of the developed diagnostic system is to perform a 100% end-of-line quality control for several different types of electric motors. The system must detect and identify, with high reliability, the potential defects of the manufactured product, as well as any deviations from the nominal characteristics resulting from either its electronic, electrical or mechanical components. In doing so, it should facilitate the change of the product type and shorten the time required for the change.

Innovation

In developing such flexible diagnostic systems, innovations are embedded in several areas. First of all, in the semi-automatic or automatic gripping of products. Furthermore, in the procedure of achieving working conditions and finally, evaluating the measured results, both on the basis of the parameters obtained from the database or MES system. At the same time, solutions are sought to reduce the duration of the process and increase the reproducibility of the results.

Effects

With the development of such multi-product diagnostic systems, we are able to ensure 100% quality control of products, with an increased efficiency dictated by the high competition in global markets.
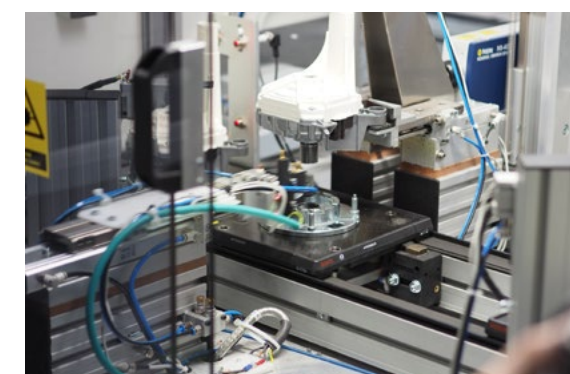
Areas of Application

The current application scope is the production of electric motors for vacuum cleaners and household appliances.
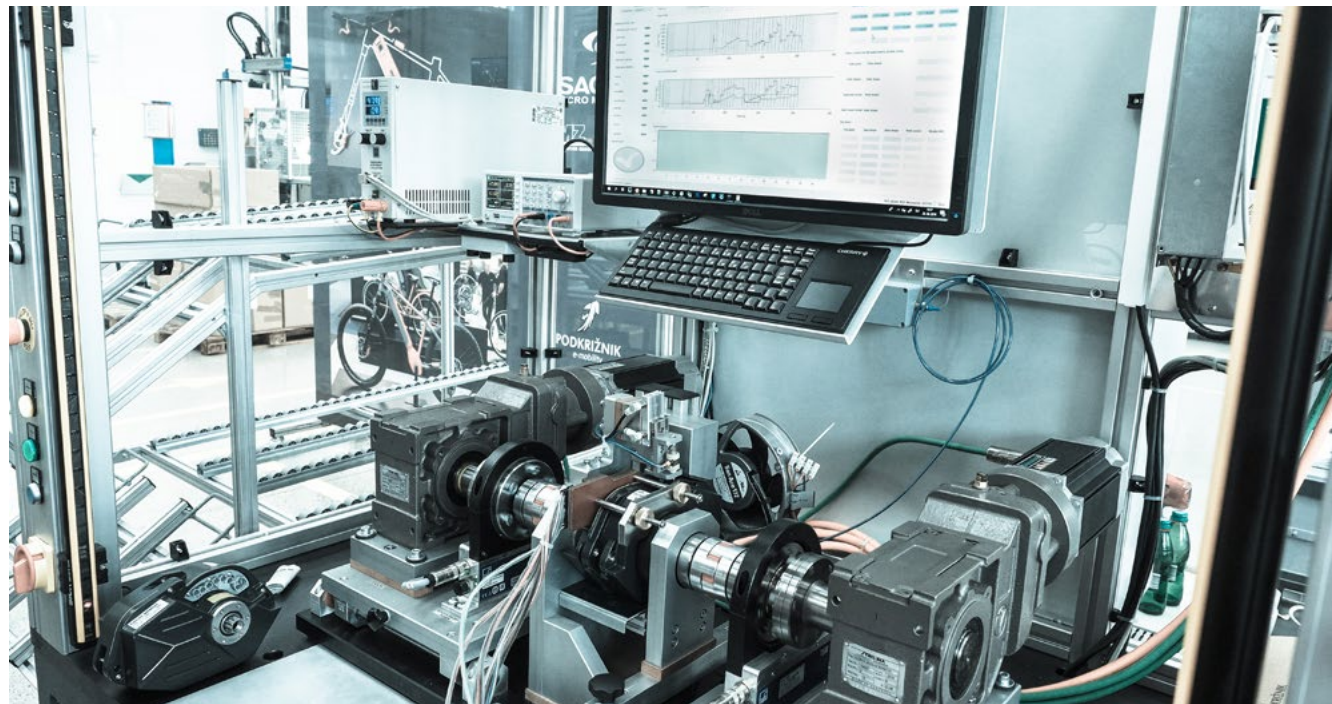
Contributing Partners

- Jožef Stefan Institute – Department of Systems and Control (dsc.ijs.si)
- Nela d.o.o. (www.nela.si)

More Information

- dr. Gregor Dolanc (gregor.dolanc@ijs.si)

DIAGNOSTIC SYSTEM FOR END-OF-LINE QUALITY ASSESSMENT OF THE PEDELEC E-BIKE DRIVES

The developed system enables complete final quality control of manufactured pedelec e-bike drives.

Purpose

In recent years, Slovenian companies have focused on the production of more complex products with a higher added value. They also represent a technological challenge from the point of view of quality assurance of the finished product and production without leftover. During the end-of-line quality control of the e-bike drive assembly, it must be ensured that the produced units are in perfect condition. That applies for the individual assemblies (motor, gearbox, sensors and electronics), as well as for the product as a whole. Its operation must therefore be tested over a range of intended loads, requiring repeated sets of measurements to be made at several operating points.

Function

The main function of the e-bike drive diagnostic system is to detect and identify the potential defects of the manufactured product and any deviations from the nominal characteristics resulting from either its electronic, electrical or mechanical components. Thereby, reliability and reproducibility of the measurements performed are of paramount importance. The prerequisites for this are the provision of constant operating conditions and the associated elimination of external influences (such as vibrations, electrical disturbances). To suffice these requirements the appropriate mechanical construction, electrical and electronic equipment, as well as a carefully designed diagnostic procedure are essential.

Innovation

Innovation in the development of industrial diagnostic systems is evident in several areas. First of all, in recording the exact working conditions when acquiring the measurements and storing the data in the database. Furthermore, in the identification, formulation and fine-tuning of features for the detection and localisation of specific production defects from vibrational, electrical or other signals. In addition, innovation is also demonstrated in the construction approaches, that increase the suppression of environmental disturbances, as well as improve handling and ergonomics.

Effects

With the development of the latest generations of diagnostic systems, we can ensure 100% quality control of products even for more complex electromechanical assemblies. With minor modifications, this scope can be extended to a wide range of such products.

Areas of Application

The current field of application of the described diagnostic systems is the production of electric motors for vacuum cleaners and air conditioners, as well as electric drives for Pedelec type e-bikes.
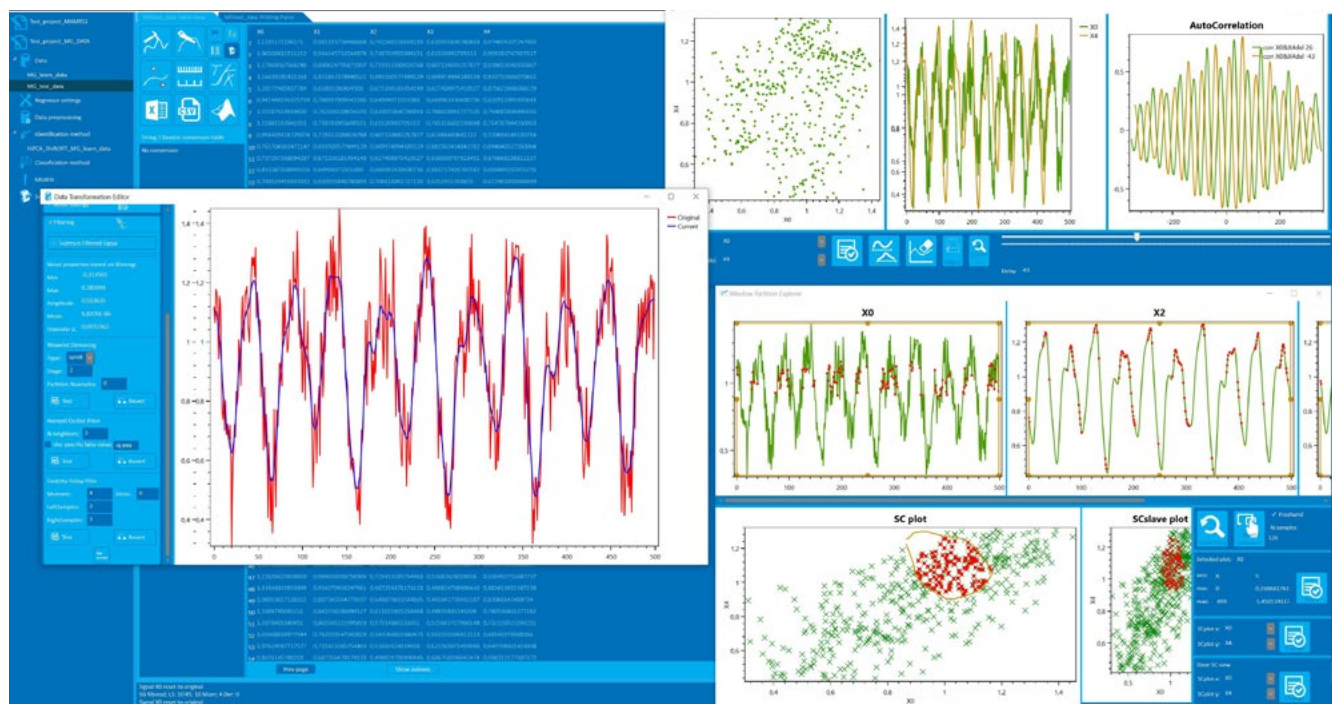
Contributing Partners

- Jožef Stefan Institute – Department of Systems and Control (dsc.ijs.si)
- Nela d.o.o. (www.nela.si)
- Podkrižnik d.o.o. (www.podkriznik.si)

More Information

- dr. Gregor Dolanc (gregor.dolanc@ijs.si)
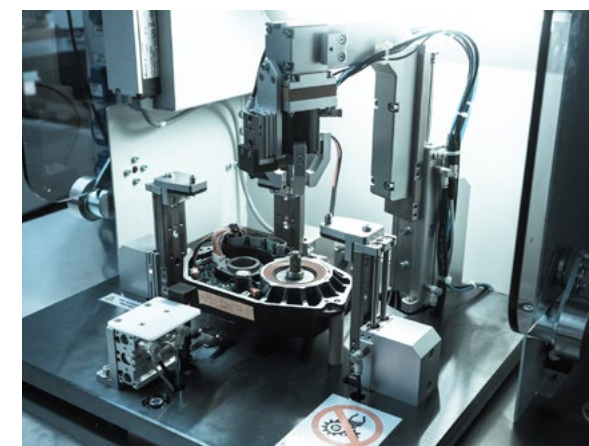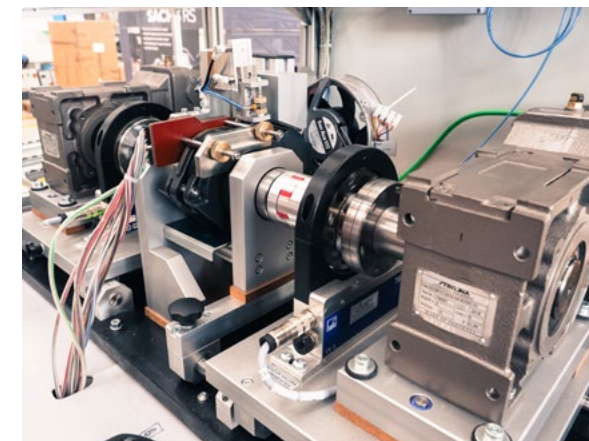
SMARTS – SMART SENSOR DESIGN PLATFORM

An effective process control requires a range of data, some of which is directly measurable while some can only be evaluated by means of soft or smart sensors. The developed platform enables the acquisition of additional information on the current state of the process on the basis of measurable data and the appropriate model – digital twin of the process.

Purpose

Modern industrial systems consist of different dynamic processes with a complex structure and frequently operate under changing environmental conditions. Because of this, intelligent and advanced data-driven methods appear to be an appropriate tool when dealing with fault detection and fault diagnosis. The main purpose of the project was to develop a platform for smart sensors design for process-monitoring purposes, where we chose the HVAC system (Heating, Ventilation and Air Conditioning) as a sample process. Furthermore, we obtained a large amount of data from the real HVAC process for modeling and simulation purposes. Finally, using the platform we have developed a digital twin representation of the HVAC process.

Function

By using both, the developed digital twin and the real data of the HVAC process, we could effectively detect various faults and deviations in the process operation. Moreover, the usage of the digital twin allows us an advanced energy efficiency monitoring of the whole HVAC system, as well as isolation of the fault causes of the individual components of the HVAC system.

Innovation

The development of the digital twin and the implementation of the self-evolving intelligent data-based

methods for fault detection and diagnosis. The developed method adapts the parameters of the local models of the digital twin in an online manner based on the real data stream.

Effects

Quick and on-time fault detection in processes contributes to a more efficient operation of the whole HVAC system. Moreover, we reduce the operating costs through predictive equipment maintenance.

Areas of Application

Mainly in air-conditioning and process automation. The developed platform is tested in a real environment within the energy management portal, which is set up in METRONIK and could also be used in various process industries.

Contributing Partners

- Metronik d.o.o. (www.metronik.si)
- University of Ljubljana, Faculty of Electrical Engineering, Laboratory of Control Systems and Cybernetics (lak.fe.uni-lj.si)

More information

- Aljaž Stare (aljaz.stare@metronik.si)
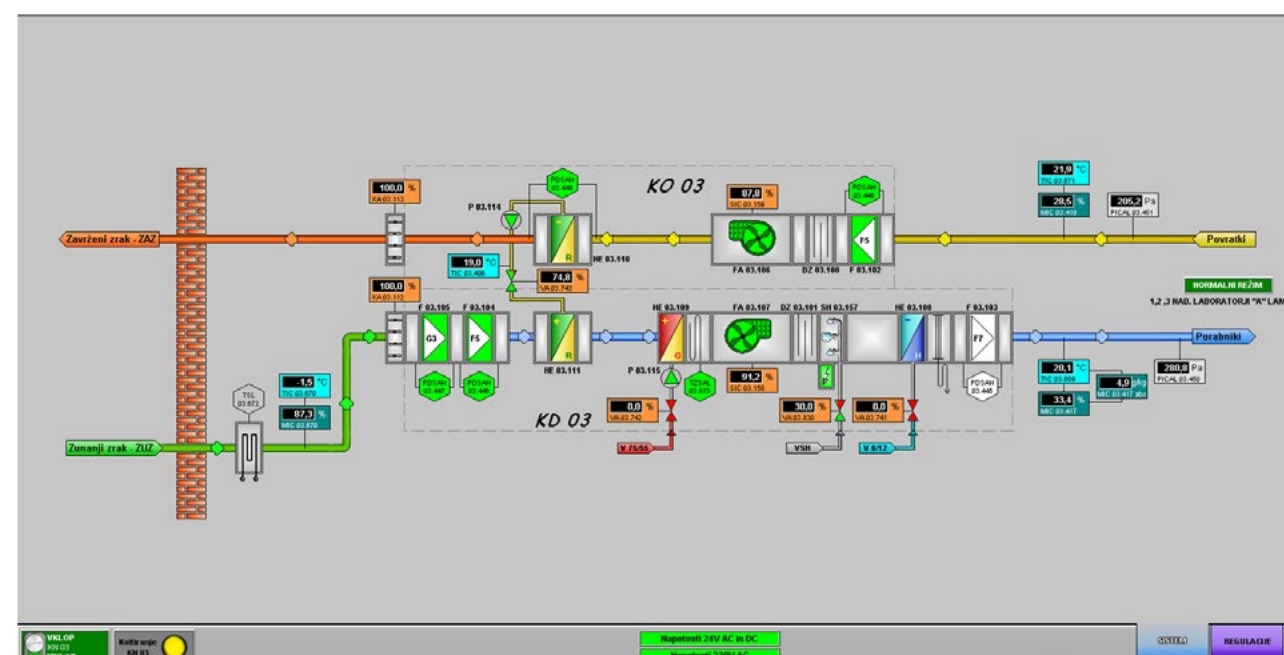
TOOL FOR ANALYSIS OF PRODUCTION PARAMETERS' IMPACTS ON THE FINAL PRODUCT QUALITY

Process variations often have unexpected impacts on the final product quality. The developed tool enables the identification of those production parameters that affect the final product's quality most significantly. This allows us to improve our knowledge of the process and to achieve long-term reduction of waste.

Purpose

The variability of raw materials and production operations can lead to unexpected deviations in the quality of the finished products. Due to the complexity and the wide range of possible causes it is not always possible to rationally predict and evaluate all the impacts on the final product quality in advance. The digitalisation of production processes opens up the possibility of ensuring complete traceability of production, from raw materials, production assets and performed operations, to the final control of product quality. A systematic analysis of such digital traces of products can help discover and understand the impacts and causes of the final product quality deviation. In the long run, all this can lead to better product quality management and be a step towards the realisation of a zero-defect production.

Function

The developed software tool enables the analysis of how production variability impacts product quality, as it joins together the basic functions necessary for the analysis of historical production data in one place. The tool's web interface enables a systematic review and selection of analysed data, analysis and interpretation of the impact of the individual production variables and identification of models that can be used to check »what-if« scenarios or predict the final product quality before all production operations are completed.

Innovation

The developed tool simplifies the necessary steps for a systematic analysis of production data, which can affect the final quality of the product. The tool is based on the integration of analytical web services, which enables quick customisation and new functional extensions according to the specific needs of end users.

Effects

The introduction of a systematic approach to identify causes of product quality deviation based on data analysis leads to a better understanding and management of the considered production process. Consequently, product quality could be improved and waste could be decreased.

Areas of Application

The tool can be applied in the areas of production where unclear impacts on the final product quality need to be determined. To verify the usefulness of the tool it was applied to the analysis of the impact of the balancing machine on the final quality of electric motors on the production line ML-14 in Nela d.o.o.

Contributing Partners

- Nela d.o.o. (www.nela.si)
- Jožef Stefan Institute – Department of Systems and Control (dsc.ijs.si)

More information

- Andrej Biček (andrej.bicek@domel.com)
- Miha Glavan (miha.glavan@ijs.si)
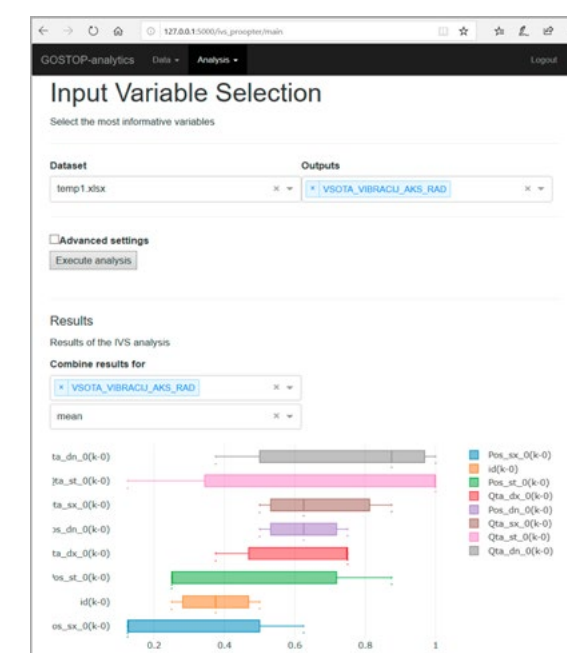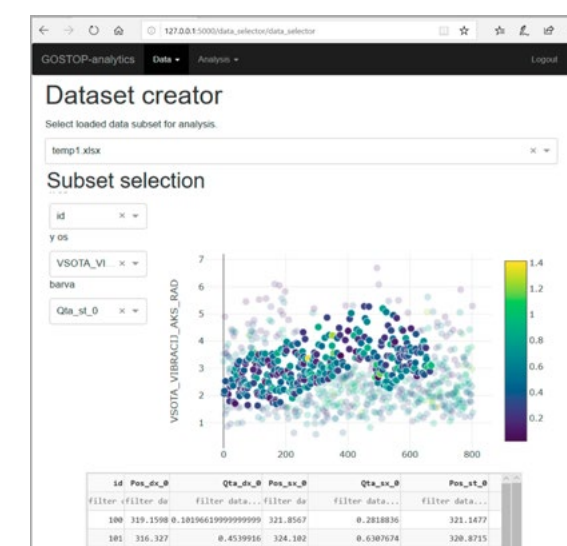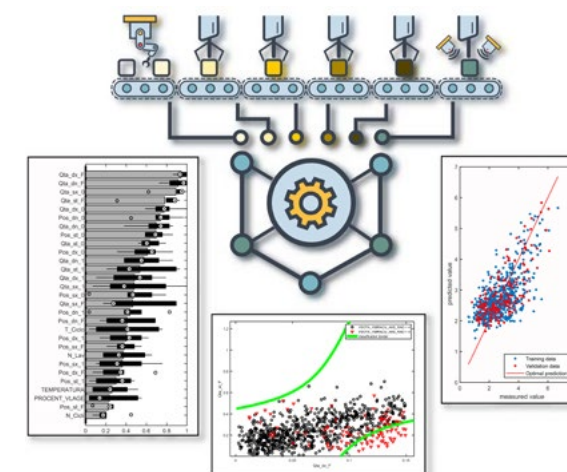
SUSTAINABLE SYSTEM PLATFORM

Sustainable System Platform for Industrial Automation and Manufacturing Intelligence.

Purpose

Sustainable System Platform is a software application installed at your plant, that continuously monitors your production applications and system hardware, identifies upset conditions and alerts you to potential issues before they manifest into real problems, such as software application errors or machine downtime events.

Function

Sustainable System Platform has been engineered to fit into your environment and give you proactive visibility into the problems you might experience with your production environment. Sustainable System Platform Includes:

- **Intelligent Software Tool** – Supervision of software applications and system health for easy maintenance. The evolving solution allows a faster response to new alert conditions and environmental factors and enables more effective corrective actions

- **Integrated Documentation System** – The centralised documentation system allows you to keep up-to-date documented details of the involved integrated systems in your production environment on different levels – from simple terminal devices to complex systems, like SCADA, MES, ERP, etc.

Sustainable System Platform monitors many unique system attributes, metrics and system parameters, like:

- Industrial system platform: runtime monitoring, redundancy/failover, events error/warnings and other
- I/O connectivity: connection status, I/O server status, event error/warnings
- Historian: historian service status, database health, event error/warnings

- MES: service status, database performance, event error/warnings
- SQL server: internal performance & health, maintenance plan management
- Reporting: performance & health, slow query detection, event error/warnings
- Hardware/OS: CPU, memory, event logs, performance counters

The platform also monitors all system changes of the different systems involved in the production environment, from simple configuration settings changes to complex SCADA/MES business logic layers.

Innovation

- Maximised system availability and increased production yield and revenue by:
  - Dentifying and addressing issues early on to avoid adverse effects on operations
  - Reducing resolution time with pinpoint error detection
- Increased human resource efficiency with:
  - Automated system management
  - Reduced volume of high priority tasks
  - Simplified diagnostic process with precise and contextual alert notifications
- Automatic fault identification, recovery and troubleshooting:
  - Flexible configuration of fault conditions and fault-recovery actions
  - Ability to customise and integrate other services, including their own health check services and auto/manual recovery actions

Effects

- Up to 30% lower maintenance and training cost
- Proactive detection of potential failure reduces critical errors and downtime events
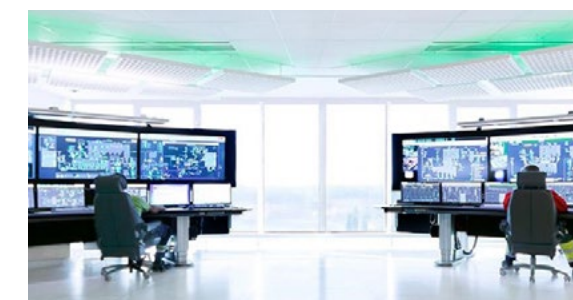
Areas of Application

Production environments with industrial automation, manufacturing intelligence and production process optimisation.

Contributing Partners

- INEA d.o.o (www.inea.si)
- University of Ljubljana, Faculty of Electrical Engineering (www.fe.uni-lj.si)

More Information

- INEA d.o.o (info@inea.si)

Sustainable System Platform

MES PLUGIN FOR ANALYSIS AND OPTIMISATION OF PRODUCTION

MES plugin enables additional functionality of the IIoT platform for managing production with accurate information in real time for making correct decisions.

Purpose

The Industrial Internet of Things (IIoT) is an important part of the digital transformation within industry 4.0. Sinapro.IIoT Analytics is a powerful easy-to-use business analytics solution, that will help you improve operational efficiency, optimise your productivity, improve your delivery precision, increase your revenues and gain a competitive edge in the market. Sinapro.IIoT Analytics will give your staff easy access to actionable information about operational performance, key performance indicators - KPI and more.

Function

- OEE Overview - presentation of the OEE value, availability, efficiency and quality
- Availability Analysis - direct and easy access to availability figures for machines, lines, teams, shifts ...
- Downtime Analysis
- Product and Order Analysis
- Quality Analysis
- Speed Analysis
- Machine Report
- Availability data and order data
- Loss Cost Analysis - see the costs of disturbances
- Maintenance Analysis
- ...

Innovation

The developed solution is characterised by a simple implementation and a user-friendly environment for everyday use. The integration of the latest IT technology, such as Cloud, CEP, in memory database, load balance, industry standard communication, AR, security, and others, enables the greatest effect in everyday use in the industry.

Effects

Some of the effects in production:
- Get full control - Provides real-time production information available for all levels in the organisation and powerful analysis tools
- Improve productivity - Enables continuous improvement, resulting in increased efficiency and productivity
- Increase and secure output - Facilitates your planning for precise delivery and increased total production output
- Minimise efforts to follow up production performance
- Improve quality – Enables an analysis of data from quality-related disturbances on the machine or product, which has a direct impact on OEE
- Get the facts - Ensures easy access to reliable data needed for decision-making on improvements, investments and changes in production flow
- Quick return on investment
- Be ready for Industry 4.0 – Get digital

Areas of Application

Sinapro.IIoT Analytics is an essential part of the Smart factory of the future and a key element of Industry 4.0. It is also a condition for the implementation of a digital transformation of your production processes, based on internationally accepted architecture of Industry 4.0 RAMI 4.0 (IEC 62890, IEC 62264, IEC 61512 ...)
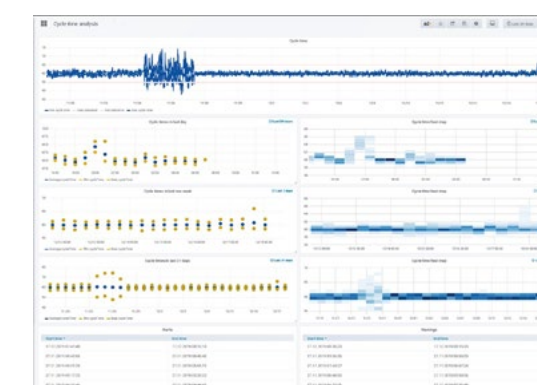
A high level of integration into various info systems enables Sinapro.IIoT Analytics to be used in various fields of industry.

Contributing Partners

- KOLEKTOR GROUP d.o.o. (www.kolektor.com)
- Jožef Stefan Institute – Department of Systems and Control (dsc.ijs.si)

More information

- Klemen Mehle (klemen.mehle@kolektor.com)

Sinapro.IIoT – SMART PLATFORM FOR Smart MES

The Industrial Internet of Things (IIoT) is an essential part of the Smart factory concept in Industry 4.0.

Purpose

The Industrial Internet of Things (IIoT) is an important part of the digital transformation to Industry 4.0. Sinapro.IIoT helps with the integration of IIoT devices and other industrial sensors and equipment for the collection and processing of the information generated by the machine. Event signals and condition data are highly relevant and can be used directly in the Sinapro.IIoT products. The integration of IIoT devices can be used for Condition Based Maintenance and a visualisation of Production Efficiency. The in-built functionalities of the automated analysis products, machine learning and artificial intelligence (AI) allows the data to be used for Predictive Maintenance, Predictive Bottleneck Analysis and to achieve other Smart Factory benefits.

Function

In accordance with the architecture of the Smart factory in Industry 4.0 Sinapro.IIoT platform includes:
· Capture and visualisation of data from devices, sensors, machines, applications, processes …
· Real-time data analysis with the help of machine learning, AI …
· Mobile access to data and analysis via computers, tablets, phones …
· Integration with existing and new systems
· Built-in data and information security mechanisms
· IIoT cloud or on-site service

Innovation

The developed solution is characterised by a simple implementation and a user-friendly environment for everyday use. The integration of the latest IT technology, such as Cloud, CEP, in memory database, load balance, industry standard communication, AR, security and others enables a maximal effect in everyday use in the industry.

Effects

Optimisation across the board:
· Increase productivity by 5-8%
· Improve yield, reduce scrap and rework costs by 15-25%
· Reduction in warranty costs due to defects by 10-20%
· Improve asset utilisation / ROA by 3-5%
· Reduce training time for new workers or up-skilled workers
· Improved workforce flexibility and satisfaction
· Increased operational performance
· Reduced burden of compliance and traceability

Areas of Application

Sinapro.IIoT platform is an essential part of the Smart factory of the future and a key element of Industry 4.0. It is also a condition for the implementation of the digital transformation of your production processes, based on the internationally accepted architecture of Industry 4.0 RAMI 4.0 (IEC 62890, IEC 62264, IEC 61512 …) and is compliant with many standards, such as ISA95, MESA, CEP …

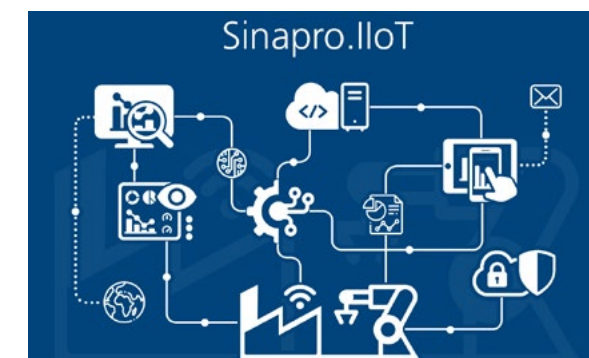A high level of integration into various info systems enables Sinapro.IIoT to be used in various fields of industry.

Contributing Partners

· KOLEKTOR GROUP d.o.o. (www.kolektor.com)

· Jožef Stefan Institute – Department of Systems and Control (dsc.ijs.si)

More information

· Klemen Mehle (klemen.mehle@kolektor.com)

AUDIO-VISUAL IoT SENSORS

Solutions with IoT sensors for faster and streamlined work of warehouse workers.

Purpose

Due to poor practicality of commercial products for order picking available on the market, the efficiency of warehouse workers can be very low. The aim of the project was to improve support for warehouse workers in larger warehouses, which can be achieved with the implementation of new technologies (smart glasses, voice communication, and artificial vision). We analysed the usability of the newest IoT sensors and developed applications for more efficient order picking. Furthermore, we examined the impact of these solutions on the users' health and well-being.

Function

Four modules were developed in the scope of the project:

- Navigating through the warehouse using voice and text commands
- Recognition of picked objects
- Scanning several bar codes at the same time
- Voice support for workplace supplies

Innovation

The solution is unique for its human-machine interfaces, that allow warehouse employees to work mostly hands-free.

Effects

The solution makes order picking easier and allows warehouse workers to work faster and more efficiently.
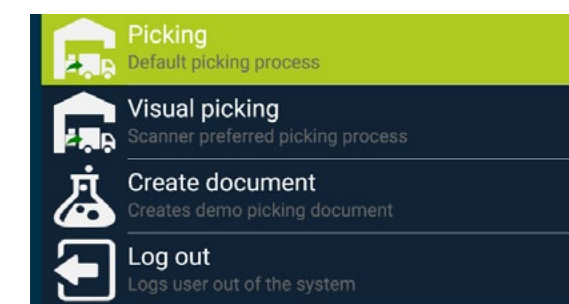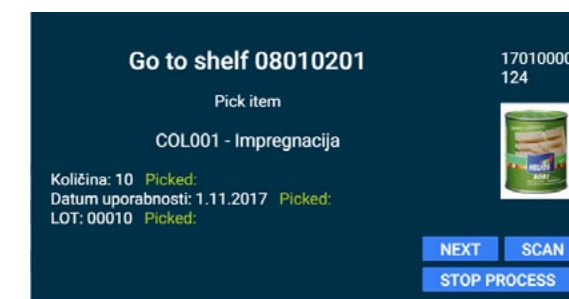
Areas of Application

In Industry 4.0-ready warehouses.

Contributing Partners

- Špica International d.o.o. (www.spica.com)
- University of Ljubljana, Faculty of Electrical Engineering (luks.fe.uni-lj.si)
- University of Maribor, Faculty of Logistics (fl.um.si)

More information

- Luka Vidmar (luka.vidmar@spica.com)

FAST MACHINE INTERLOCK SYSTEM

A fast, flexible and reliable machine interlock system (MIS) is a safety feature, that every machine needs to prevent it from harming its users or damaging itself, primarily when it operates at high energies.

Purpose

A fast, flexible and reliable machine interlock system (MIS) is a safety feature, that every machine needs to prevent it from harming its users or damaging itself, primarily when it operates at high energies. Most machines in our everyday use, such as cars, washing machines, lifts and microwave ovens, have an MIS, but the presence of an MIS is even more important in Big Physics machines, which often operate at much higher energy levels and are thus prone to greater damage in case of a malfunction.

Function

The correct choice of MIS architecture and its electronics components can have a large influence on the achievable level of dependability of the whole Big Physics facility. There is a kind of yin and yang, a duality of opposing and complementing principles, regarding the interlock system architecture – an MIS can safeguard availability, by preventing damage to the accelerator equipment, however, on the flip side, it can diminish system availability due to internal errors and failures.

Innovation

The fast MIS that we have developed has a proven hardware platform and utilises powerful and radiation-tolerant FPGAs, based on non-volatile flash technology. It also enables redundancies of the power supply, hardware components and logic and is fully configurable from the industry standard and open-source software infrastructure EPICS.

There was one user requirement that was of special concern to us: guaranteeing a response time (RT) ≤ 5 µs for failures in the crucial parts of the accelerator. We achieved a short and deterministic interlock local RT of less than 400 ns, repeatable at 20 ns, and an interlock global RT of less than 700 ns (with two MIS units interconnected with a 0.5 m optical cable).

Effects

Big Physics machines, such as accelerators, widely vary in size, cost and complexity, which means that in some instances the MIS may be just a small part of the Machine Protection System (MPS), while in others it may constitute almost the entire protection system. Based on discussions with several accelerator facilities around the world, we have determined that the requirements of the greater part of the community could not be met with commercial, off-the-shelf equipment. Therefore, we designed a reliable software and hardware product that is an out-of-the-box solution for the MPS engineer.

Areas of Application

The fast MIS platform, designed by Cosylab and manufactured by SINAP, is an autonomous and significantly scalable and adaptable system. Our solution presents an industrial-grade high-tech solution, which covers all common MIS functionality with the speed, flexibility, reliability, availability, determinism and a consistent response, which is what modern Big Physics facilities need from a robust Machine Protection System.
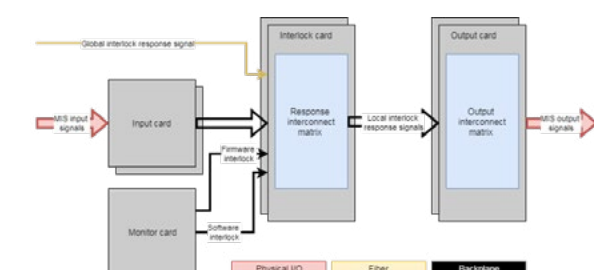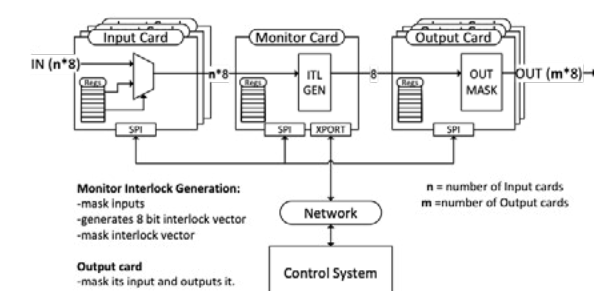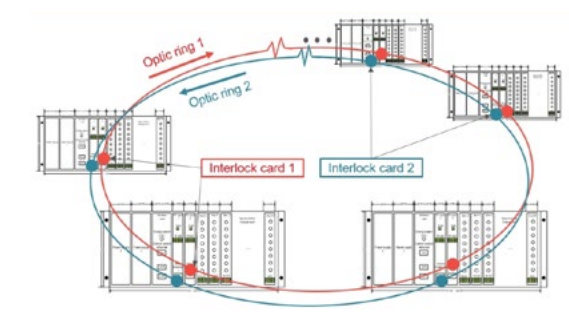
Contributing Partners

- Cosylab, d.d., Control System Laboratory (www.cosylab.com)

- University of Maribor, Faculty of Electrical Engineering and Computer Science (feri.um.si)
- SINAP, Shanghai Institute of Applied Physics, Chinese Academy of Sciences (english.sinap.cas.cn)
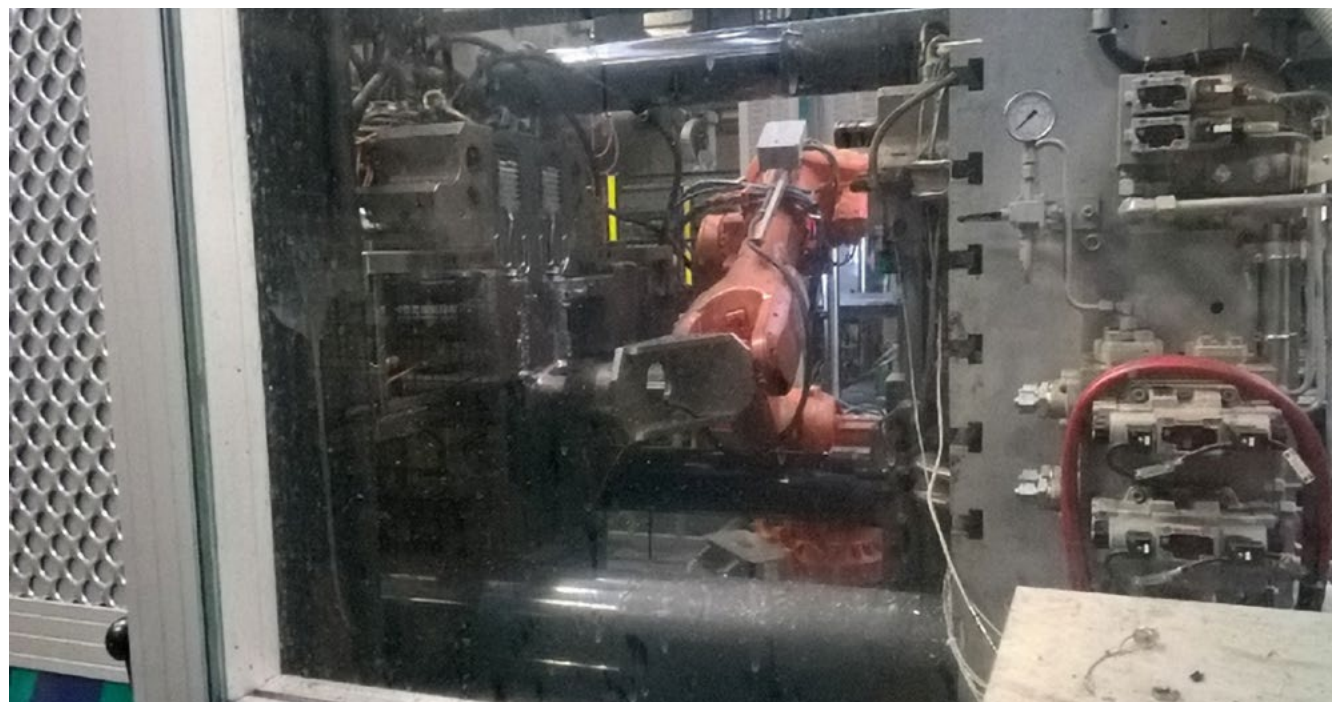
More information

- Cosylab, d.d., Laboratorij za kontrolne sisteme (info@cosylab.com)

TOOLING

SMART TOOLS FOR PRESSURE DIE CASTING AND PLASTIC INJECTION MOLDING

Industry 4.0 is increasingly penetrating into the die casting and injection molding processes. Accordingly, smart tools for plastic injection molding and die casting equipped with sensors and actuators allow for better control, further optimised operating and a better understanding of the aluminium die casting and injection molding process, resulting in improved product quality.

Purpose

The introduction of smart mechatronic tools in the process of aluminium die-casting and injection molding raises the efficiency of the production process and the product quality. Waste reduction, control and optimisation of production processes is the goal of all companies. With the introduction of sensor systems and actuators, the collection of large amounts of data and their analysis, this can be achieved in a much shorter period of time.

Function

Plastic injection molding and die casting machines give us an overview of many process values relat-

ed to the operation of the machine but the actual events inside the tool itself can only be inferred indirectly. The introduction of the concept of smart tools in the die casting and injection molding industry and the built-in sensor systems provide a more detailed insight into what is happening inside the tools. Based on the monitoring of two selected parameters (e.g. tool temperature and injection pressure) we can monitor the events inside the tool in real time and with the obtained data via dedicated algorithms we can optimise the process and reduce ejection.

Innovation

The installation of dedicated sensors and actuators directly into the tool is a novelty that allows the

monitoring of the process of injection molding or die casting in real time. This novelty provides new insights into the processes of injection molding or die casting, which have been relatively unknown until now. With data collection and analysis, the potential for reduced waste and a more optimal performance is enormous.

Effects

Real-time monitoring is an advantage that allows us to debug much faster and optimise the process. Using this data and analytically comparing it with the quality of the produced pieces also enables the reduction of waste and energy consumption and an increase of production productivity.
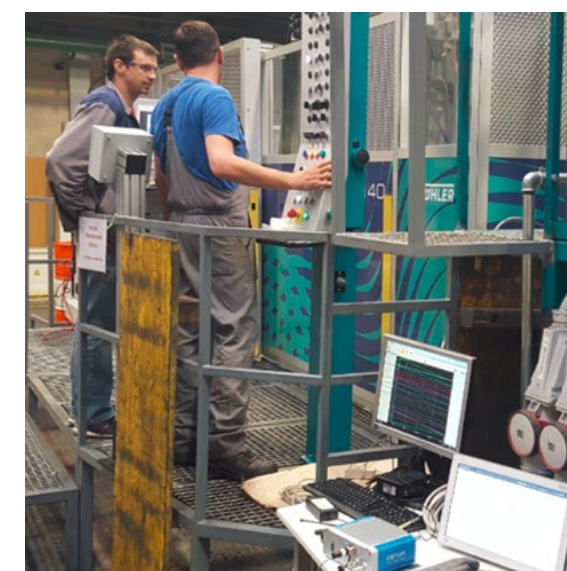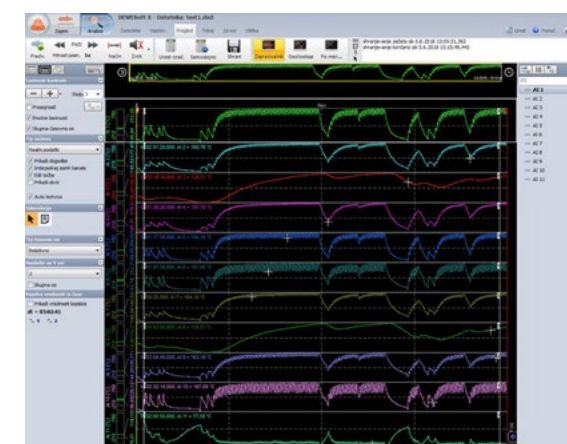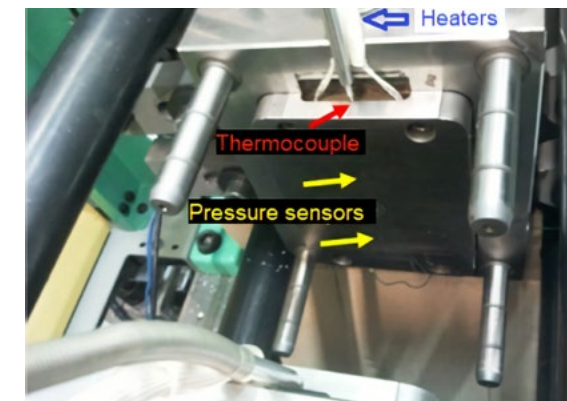
Areas of Application

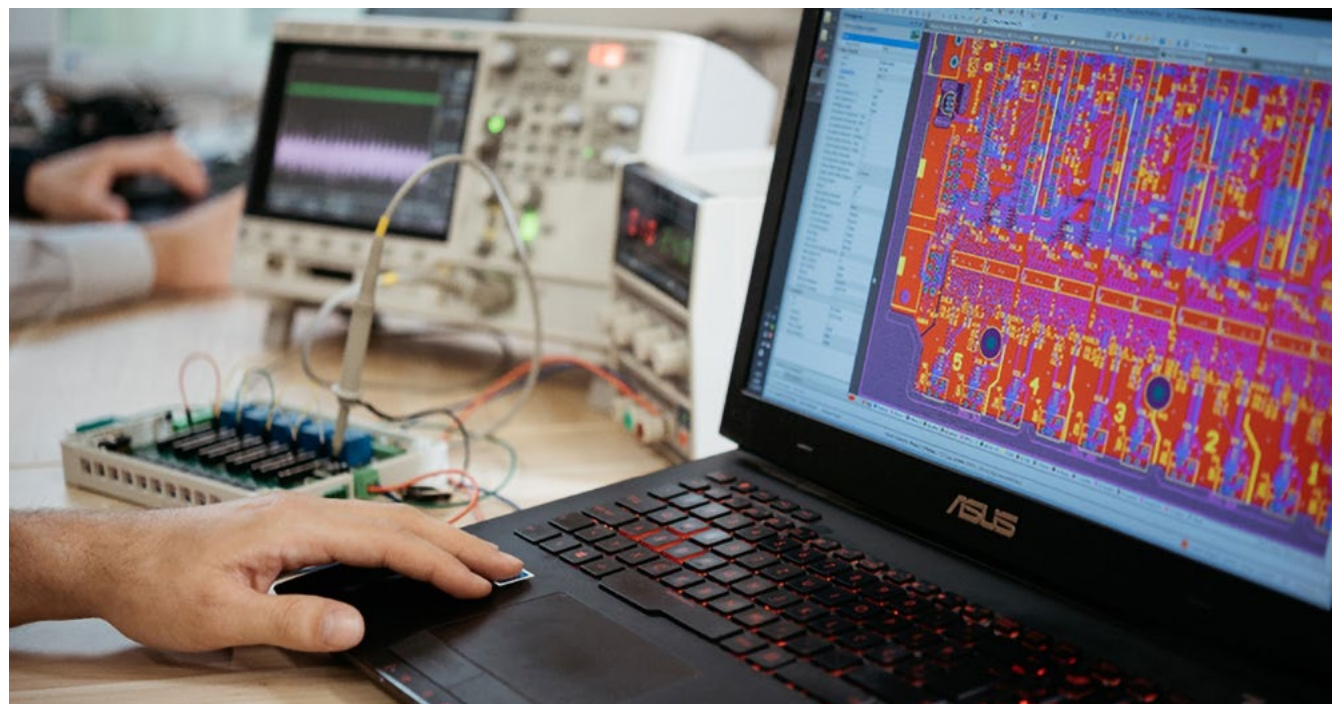Manufacturing industry (injection molding, die casting).

Contributing Partners

- NELA d.o.o. (www.nela.si)
- HIDRIA d.o.o. PE Alutec (www.hidria.com)
- L-Tek d.o.o. (www.l-tek.com)
- TECOS, Slovenian Tool and Die Development Center (www.tecos.si)
- KOLEKTOR GROUP d.o.o. (www.kolektor.com)

More Information

- dr. Dragan Kusić (dragan.kusic@tecos.si)

INTEGRATED INTERFACE FOR ACOUSTIC CONTROL OF INJECTION MOLDING AND DIE CASTING PROCESSES

An integrated interface for acoustic control of injection molding and die casting processes has been developed. We have successfully set up appropriate architectures to transfer the production data from the injection machine and the sensor data to the cloud, where we can easily display real production data in real time in accordance with Industry 4.0 guidelines.

Purpose

The manufacturers of plastic and metal products are very much concerned with the achievement and quality assurance of injection molded products produced by tools.

The developed solution is intended for continuous monitoring of injection molding and die casting processes, which enables real-time evaluation of the quality of the parts and thus, through the feedback loop, improves the entire injection molding process.

Function

The field of plastic injection molding and die casting was investigated, with an emphasis on robust usability and elimination of problems that occur daily in the injection molding and die casting processes. An integrated interface has been developed with appropriate algorithms, that enable acoustic control of injection molding and die casting processes, which makes it easier to monitor and eliminate identified manufacturing errors in real-time, with the aim of constantly monitoring the quality of manufactured products and raising the productivity of both processes.

Using the state-of-the-art technology of the Industrial Internet of Things (IIoT) world, we can capture sensitive acoustic and production data, process it on the edge, present and send it through various communication protocols (MQTT, OPC-UA...) to Cloud for further analysis and presentation.

Innovation

The developed acoustic solution is a novelty in the field of injection molding and die casting, with which we have provided direct insight into the state of individual production sequences in real time. Different tool states, injection molding quality, scrap etc. can be automatically recognized.

Effects

The new system allows the process user to have a real-time overview of production operations and the actual state of the tool. The principle of edge processing enables an improvement in the quality of the pieces produced and thus increases the productivity and economy of production.
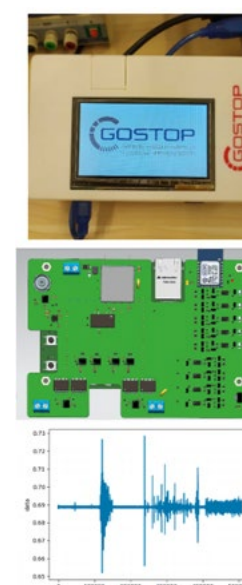
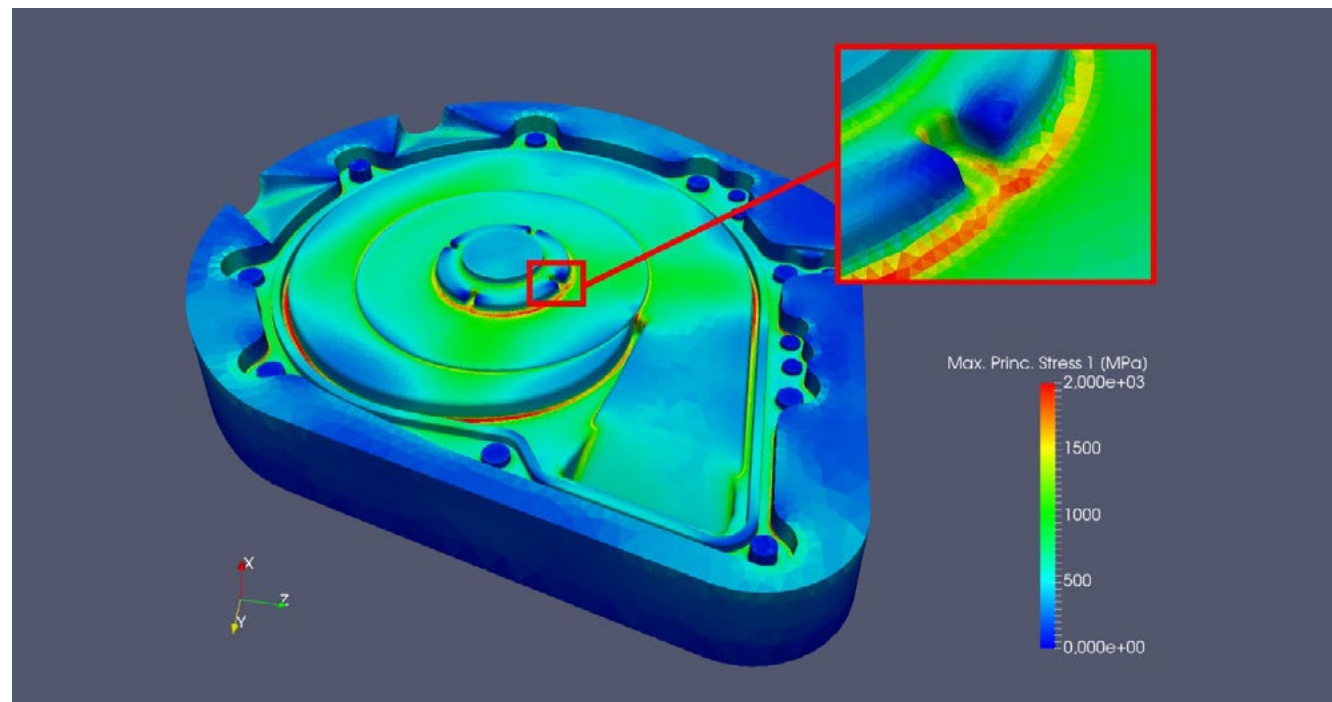## Areas of Application

Injection molding, die casting.

Contributing Partners

- TECOS, Slovenian Tool and Die Development Center (www.tecos.si)
- L-Tek d.o.o. (www.l-tek.com)
- KOLEKTOR GROUP d.o.o. (www.kolektor.com)

More Information

- dr. Dragan Kusić (dragan.kusic@tecos.si)

SOFTWARE FOR PREDICTING THE SERVICE LIFE OF HOT PARTS OF DIE CASTING TOOLS

Die casting tools are exposed to high thermal and mechanical loads. Heat cracking due to thermal cycling may shorten the service time of the tool. The developed software for predicting the lifespan of hot parts of die casting tools enables an insight into the creation of heat cracks and the possibilities of improvements in the development phase of the product.

Purpose

Customers have strict requirements regarding surface defects that the die caster must fulfil. However, formation of heat cracks is expected during the lifespan of the die casting tool and they have to be cleaned manually or automatically, which produces additional costs. That is why extra care is given to the reduction or, if possible, elimination of heat cracks.

Function

For classifying defects, especially heat cracks, computer algorithms and software were purposely developed.

The newly developed software for die service time prediction is able to analyse critical areas on the tool where heat cracks are most likely to appear. The R&D team can use the data from the simulations to optimise the casting in the design phase.

Innovation

The newly developed software for die lifespan prediction is designed as an add-on to the commercially available software MAGMASOFT, since the calculation of the temperature fields during the die-casting process on the tool is needed beforehand. With purposely developed algorithms our new software allows a more detailed insight into the formation of heat cracks, which enables the optimisation of the die tool design and cost cuts in die maintenance.

Effects

The new software allows better insight into the areas where heat cracking occurs and the underlying causes. With the results from the simulation, coupled with advanced design solutions (segmentation, 3D metal printing), we can optimise critical areas in the development phase, as well as use it as an extra added value when negotiating with potential customers. With the use of the developed software and the optimisation on the test project, the expected savings on die maintenance are up to 10%. Furthermore, there is an expected cost cut due to the reduced amount of manual cleaning.
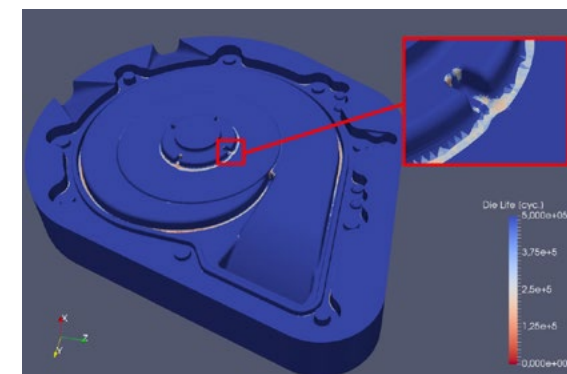
Areas of Application

Manufacturing industry (High Pressure Die Casting).

Contributing Partners

- TECOS, Slovenian Tool and Die Development Center (www.tecos.si)
- NELA d.o.o. (www.nela.si)

More Information

- Tadej Hohnjec (tadej.hohnjec@hidria.com)

ADVANCED HARD COATINGS FOR PROTECTION OF SEVERELY STRAINED COMPRESSION PINS FOR DIE CASTING TOOLS

In die casting, local compression pins are subjected to high thermal and mechanical loads. By applying advanced hard coatings on exposed parts, their functionality is improved and lifetime prolonged.

Purpose

A compression pin is a separate element of a die casting tool, which is used for local reduction of porosity in a casting. With an additional compression of parts with a higher mass we reduce the local volume loss due to shrinkage and increase the spreading of gas microporosity. The compression pins are inserted into the melt while it is still in a doughy state and the pins are under great pressure. This causes wear and consequently failure, which in turn causes production breakdowns and higher maintenance costs.

Function

In the die casting industry using long pins, different coatings have been in use for some time but only for the prevention of aluminium adhesion. However, there are no real solutions supported by research and testings dedicated to the protection of compression pins, which are exposed to chaotic conditions in the die cavity. By coating small elements, we expect an enhanced adhesion and abrasion wear resistance, improved stiffness and a prolonged lifetime of tool elements. The developed technological novelty is very attractive due to the low coating application cost and the above explained positive effects.

Innovation

Based on the requirements of our partners we identified and optimised various adaptations of tool protection, using various coating types, based on physical vapor deposition techniques, such as sputtering and evaporation. Simultaneously, we tested wear resistance of these coatings, using respective analytical techniques for measurement of composition and structure, as well as macro/micro/nanohardness, adhesion and friction coefficient.

Effects

Coating of severely strained compression pins in a die casting tool prolongs their lifetime, reduces adhesion and abrasion and enhances the sliding properties. Consequently, it reduces production breakdowns, which enhances productivity and reduces costs.
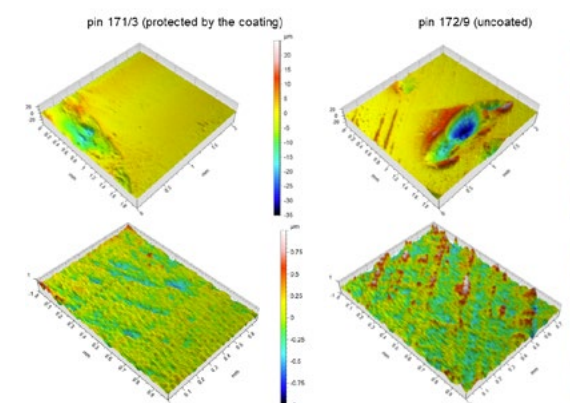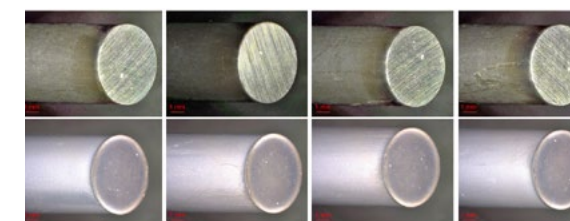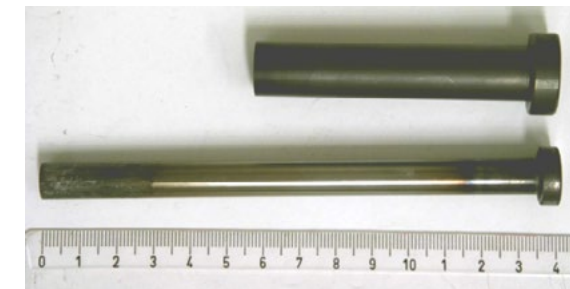
Areas of Application

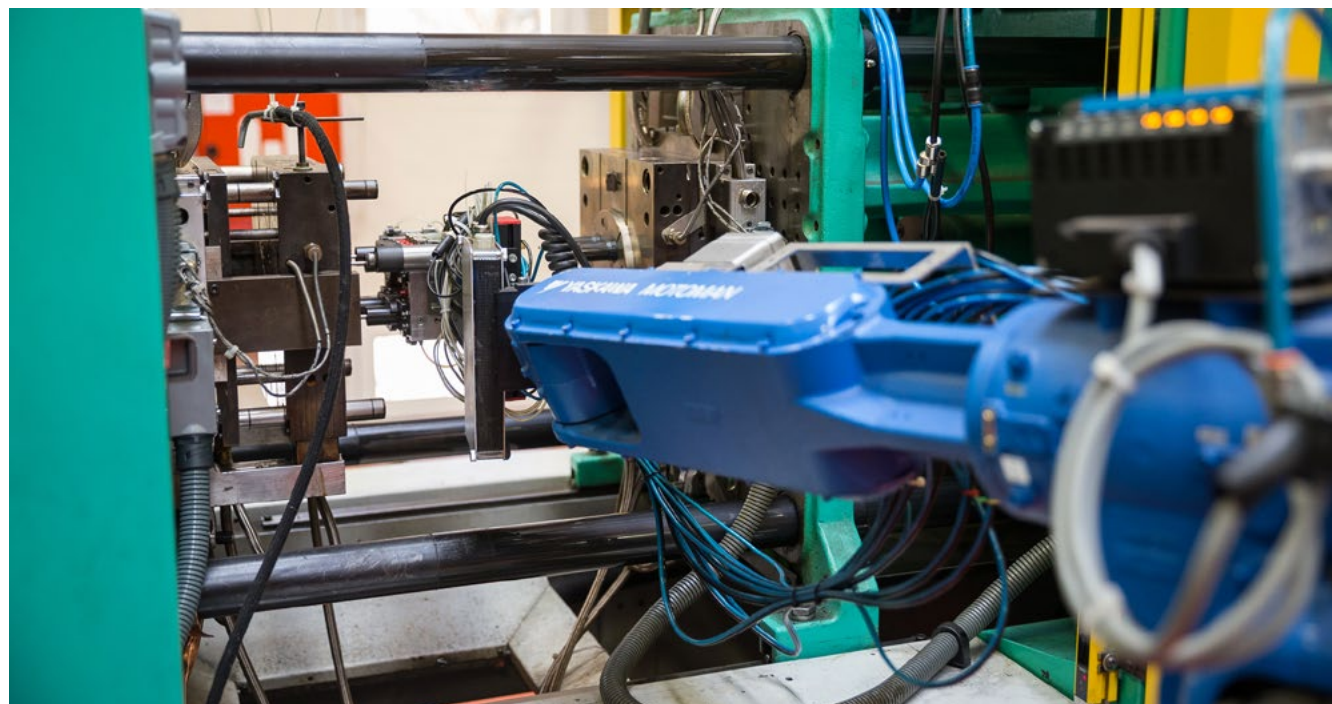Production industry (high-pressure die casting).

Contributing Partners

- NELA d.o.o. (www.nela.si)
- HIDRIA d.o.o. PE Alutec (www.hidria.com)
- Jožef Stefan Institute (www.ijs.si)

More Information

- izr. prof. dr. Miha Čekada (miha.cekada@ijs.si)

IIoT MODULE – MOULDING MACHINE ANALYSIS

The module Moulding machine Analysis provides the IIoT platform with additional functionality to monitor the performance and condition of tools on injection moulding machines.

Purpose

The module Moulding machine analysis is one of the important building blocks of the Sinapro.IIoT platform, which enables and supports the digital transformation to Industry 4.0 and is designed for:

· Monitoring, controlling and managing tools on injection moulding machines
· Monitoring the settings and operation of the injection moulding machines
· Real-time monitoring of injection pressures and other parameters
· Analysis of the data captured to improve product quality

Function

IIoT module Moulding machine analysis and its func-
tions provide a quick, user-friendly insight into the operation of injection moulding machines and associated tools. With an advanced data analysis it is possible to identify the causes of quality discrepancies, as well as the most likely reasons for the discrepancies that have occurred.

Innovation

The module Moulding machine Analysis complements the Sinapro.IIoT platform and supports the monitoring of performance of injection molding tools. The modular design allows an adaptation to the client's wishes and supports the digitisation of processes. It is based on the internationally approved architecture of factories of the future, Industry 4.0

RAMI 4.0 (IEC 62890, IEC 62264, IEC 61512 ...) and supports a number of standards, such as MIMOSA, ISA95, MESA, CEP...

Effects

Some effects in production:
· Improves machine management: comprehensive, detailed and digitised machine and tool control
· Enables collection of data about working tools for better planning of maintenance procedures
· The captured parameters on a millisecond level allow a detailed analysis of the individual injection stages
· Improves product quality - tool parameter tracking enables the on-line parameterisation of the injection moulding machine

Areas of Application

IIoT module Moulding machine Analysis is an integral part of the Factories of the Future concept, one of the building blocks of Industry 4.0 and one of the prerequisites for the digital transformation of production processes. It is applicable in all production environments where injection moulding machines are used in production processes.
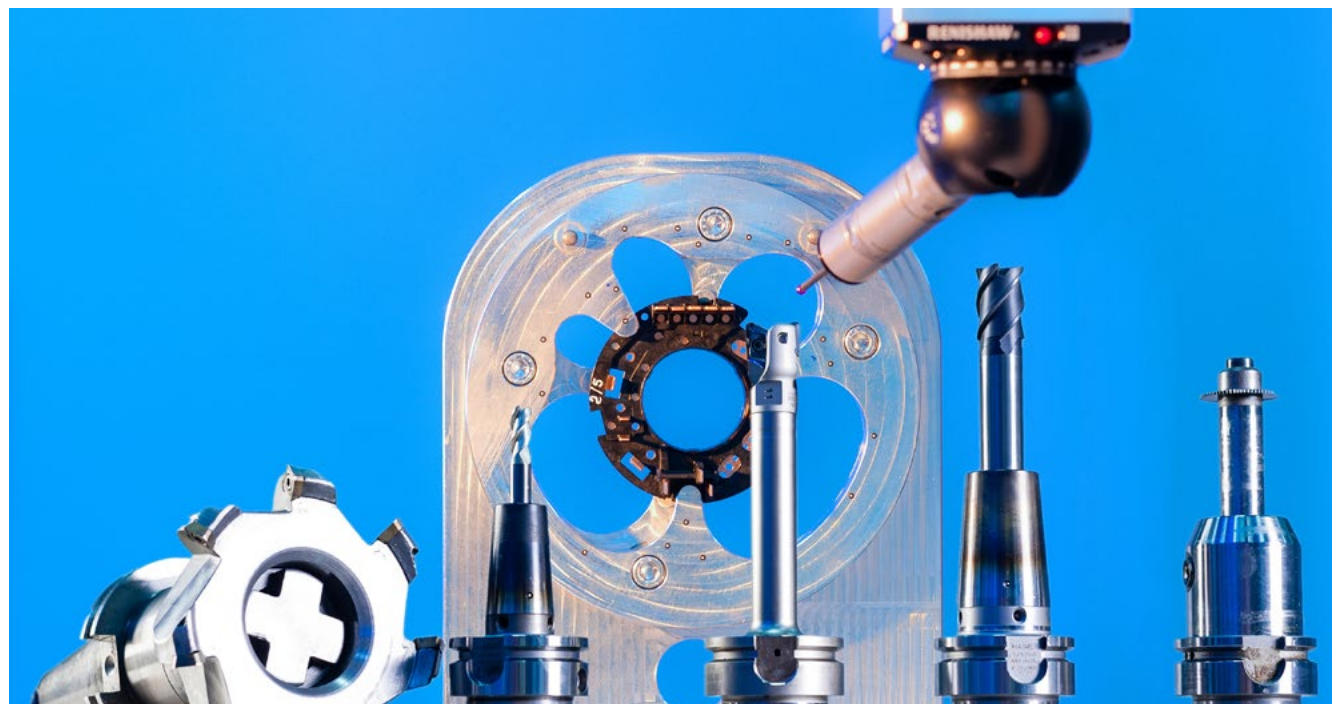
Contributing Partners

· KOLEKTOR GROUP d.o.o. (www.kolektor.com)
· TECOS, Slovenian Tool and Die Development Center (www.tecos.si)

More Information

· Klemen Mehle (klemen.mehle@kolektor.com)
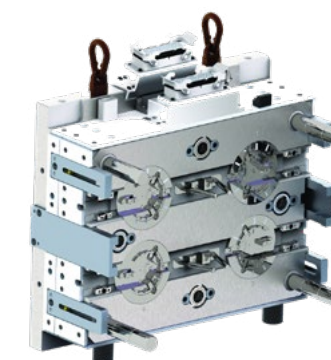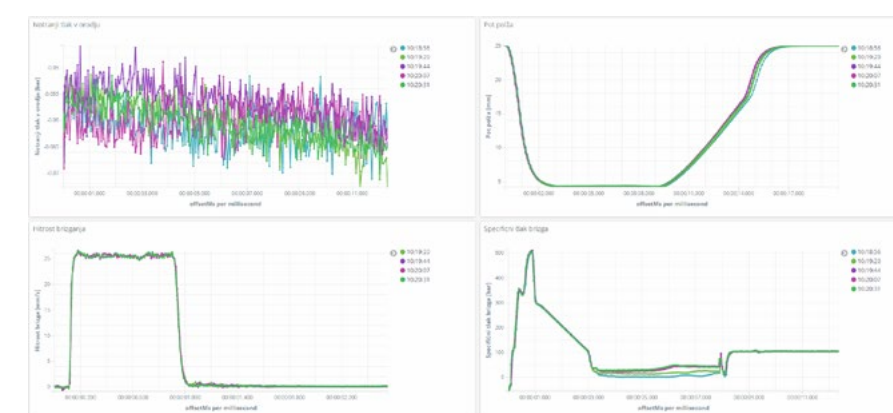
Smart MES – TOOL MANAGEMENT

The IIoT Smart MES Tool Management module provides the IIoT platform with additional functionality for monitoring the status of tools throughout their life cycle.

Purpose

The Tool Management module or "Intelligent Tool Management" is one of the important building blocks of the Sinapro.IIoT platform, which enables and supports a digital transformation to Industry 4.0 and is primarily intended for:
· Monitoring, controlling and managing tools
· Monitoring the history of tools and tool life
· Monitoring tool usage and wear
· Monitoring the condition of tools in storage and production

Function

Consistent with the architecture of the Smart factory in Industry 4.0, the Tool Management module covers the following four basic feature sets:

· Central registry of tools
· Operational task management tools
· Tool maintenance management
· Tool quality and performance management

The central registry of tools is a core functionality, while others are added based on the needs, strategic decisions and the state of existing production information systems.

Innovation

The Tool Management module complements the Sinapro.IIoT module suite and supports tool monitoring throughout its life cycle. The modular design allows an adaptation to the client's wishes and supports the digitisation of processes. It is based on the internationally approved architecture of factories of the future, Industry 4.0 RAMI 4.0 (IEC 62890, IEC 62264, IEC 61512 ...) and supports a number of standards, such as MIMOSA, ISA95, MESA, CEP ...

Effects

Some effects in production:
· Improves tool management: comprehensive, centralised, digitised tool control
· Tool information is useful for improving production planning
· Provides effective tool tracking in production
· Provides visibility of the tool - everyone can see where the tools are and in what condition they are
· Allows you to track which products were made with each tool
· Improves quality - tracking tool measurements, monitoring tool degradation, monitoring product quality, and making better decisions about when to maintain tools

Areas of Application

The Tool Management module is an integral part of the concept of factories of the future, one of the building blocks of Industry 4.0 and one of the prerequisites for the digital transformation of production processes. It is applicable in all production environments where they use interchangeable machine parts and/or stand-alone tools in production processes.
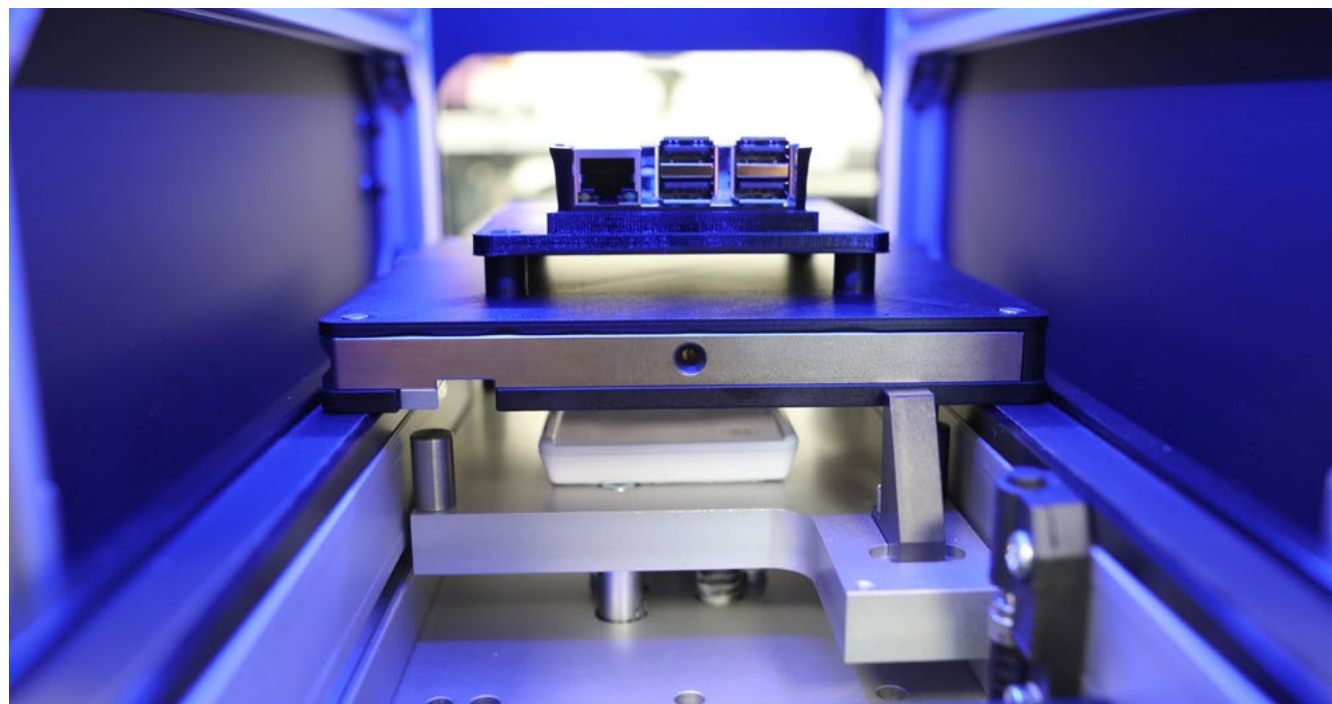
Contributing Partners

· KOLEKTOR GROUP d.o.o. (www.kolektor.com)
· TECOS, Slovenian Tool and Die Development Center (www.tecos.si)

More Information

· Klemen Mehle (klemen.mehle@kolektor.com)
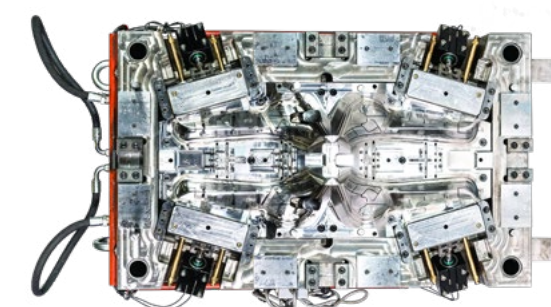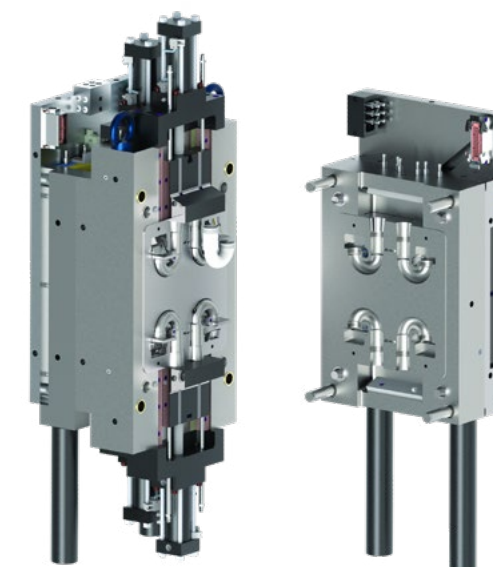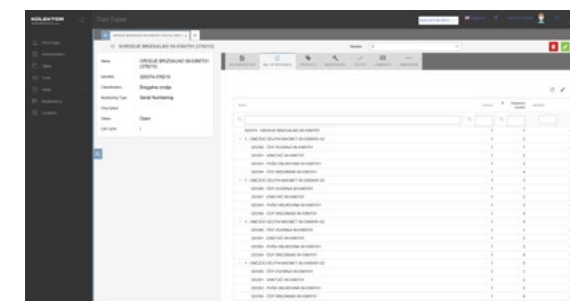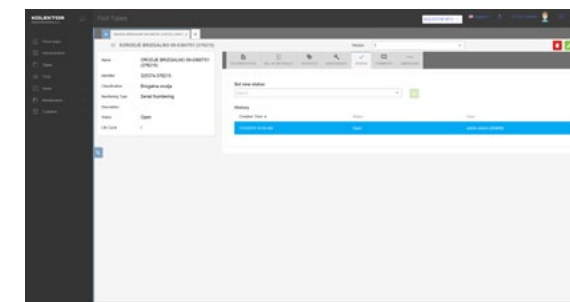
DIGITAL TRACEABILITY OF PRODUCTS

Digital traceability is an innovative solution for product tracking throughout the entire life cycle. Such tracking technology is used for products that are too small or unsuitable to attach RFID or BAR codes on, or the customer does not allow the attachments.

Purpose

The purpose of digital traceability is 100% traceability of products, for which the known tracking methods cannot be used yet. Tracking is done by using a digital twin of a real production system. The virtual production system must be an exact copy of the real system in order to introduce digital traceability. In addition, the purpose of digital traceability is to reduce unnecessary waste.

Function

The digital twin, which forms the basis for digital tracking, is designed to be »event-driven«, i.e. events

trigger a simulation. That is why it is necessary to place triggers in different places in the real system. The digital twin does not simulate forward events, but rather all the events that have already occurred.

Innovation

The solution is innovative because it provides 100% traceability for small products (too small to install an RFID code on) during production, packaging and subsequent assembly. In addition to small products, the solution can also be applied to parts where it is impossible to attach RFID codes on or the attachment is not permitted. The product in this case is an information carrier.

Effects

The effect of digital traceability is reflected in the number of cases of complaints about products which could not be traced otherwise but with this technology. With the digital traceability technology for each product manufactured, we know when the products were manufactured, what parameters were set on the machine, how fast was the performance of operations, the trajectories of different parameter curves, etc.

Areas of Application

This technology is used to track the products that, due to their geometry, do not allow the installation of RFID codes or when the customers do not allow the attachment. The area of application is primarily smart manufacturing of such products, which due to their design do not allow the installation of RFID codes or the installation is not allowed by the customers.

Contributing Partners

- University of Ljubljana, Faculty of Mechanical Engineering (fs.uni-lj.si)
- KOLEKTOR GROUP d.o.o. (www.kolektor.com)

More Information

- Matevž Resman (matevz.resman@fs.uni-lj.si)
- dr. Hugo Zupan (hugo.zupan@fs.uni-lj.si)
- prof. dr. Niko Herakovič (niko.herakovic@fs.uni-lj.si)
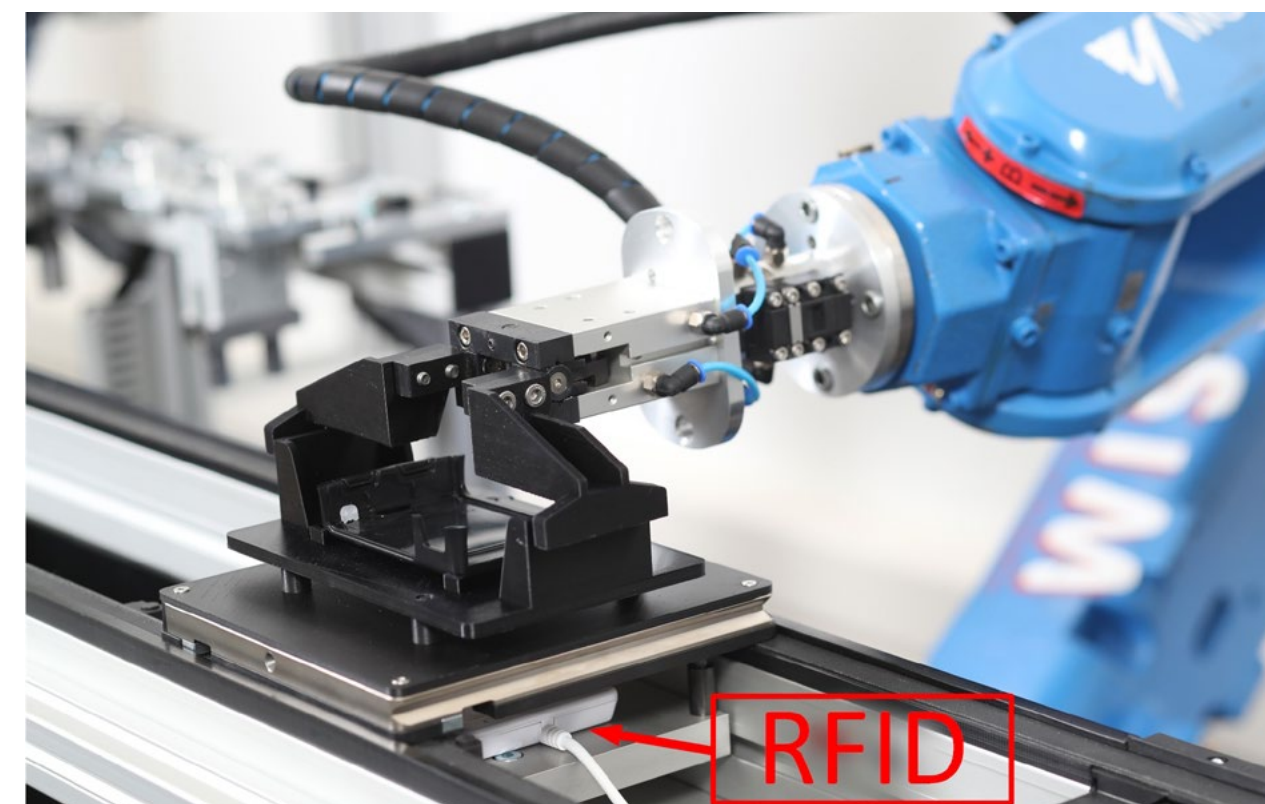
DIGITALISATION OF PROCEDURES ON THE PRODUCTION LINE

Augmented reality is one of the key enabling technologies of Industry 4.0.
Digitalisation of knowledge reduces the time and effort it takes to create written instructions and procedures for a smooth and successful knowledge transfer in manufacturing companies.

Purpose

Creating digital/visual work instructions for a quick and easy capture of knowledge, real-time video remote assistance via smart devices and process visualisation.

Function

Digitalisation is based on the REWO platform, that reduces the time and effort required to create highly engaging visual instructions to seamlessly transfer knowledge in manufacturing companies. It also enables process monitoring and real-time remote support/assistance (two-way audio/video communication) via smart devices.

Innovation

With the digitalisation of knowledge and processes (digital archiving of knowledge), we have introduced a new paradigm in the field of information capture in a production environment, which, unlike the classical written instructions, is based on a more universal approach of capturing and displaying information via video. The user-friendly application is based on the use of "drag and drop" text instructions and graphic icons/elements. The created instructions allow the processes to be divided into individual steps (step-by-step instructions), which makes it easier for employees to learn and further monitor the analytics of usage of digital instructions.

Effects

Reduced training time, faster information circulation in digital or visual (video) form, shorter preparation time and standardisation of work and processes. Remote assistance/support in real time allows a faster response time for remote locations.
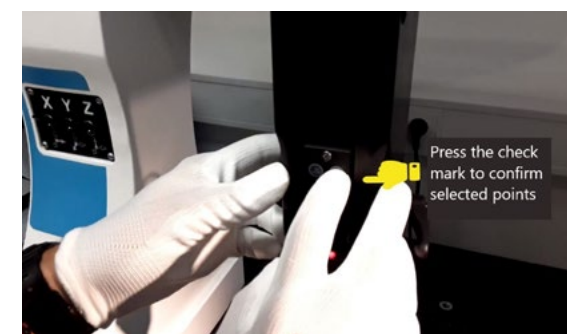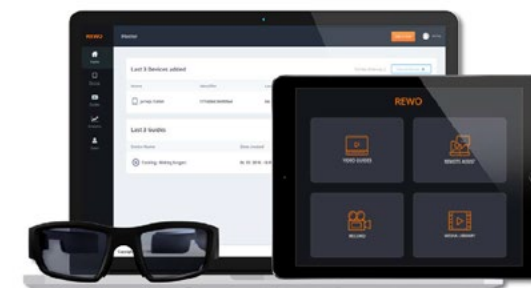
Areas of Application

Creating visual guides for standard operating procedures, worker training and re-training, quality assurance – standardised visual work procedures, training material, digital manuals and remote troubleshooting of standstills – remote support.

Contributing Partners

- KOLEKTOR GROUP d.o.o. (www.kolektor.com) with the company VIAR d.o.o. (www.viar.si), REWO platform
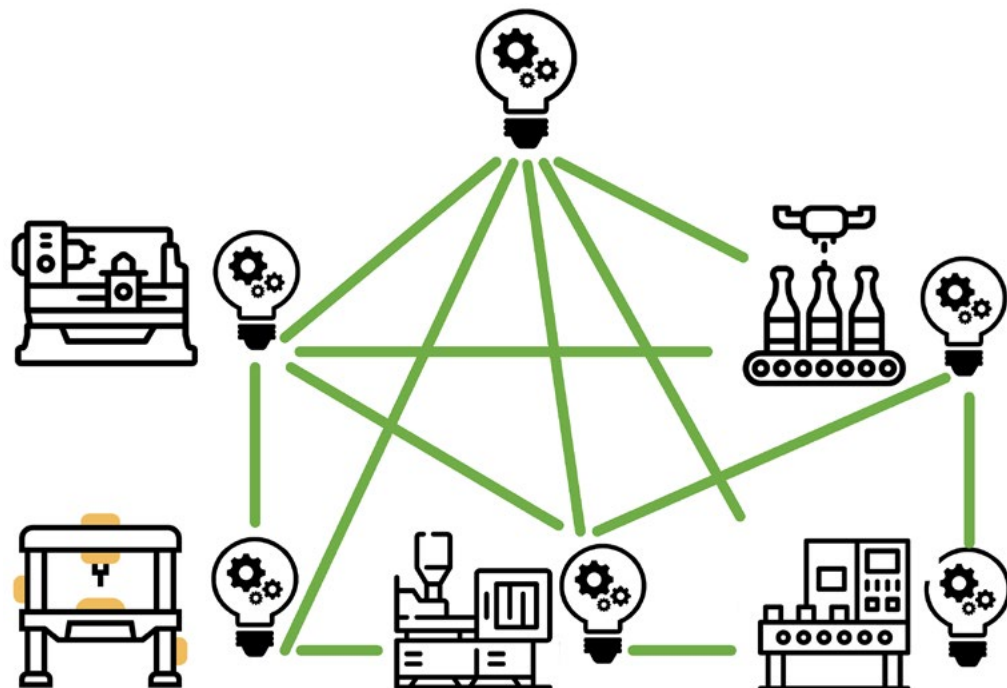
More Information

- Nejc Lisac (nejc.lisac@kolektor.com)
- Aleš Gajšek (ales.gajsek@kolektor.com)

ROBOTICS

DEMONSTRATION OF THE CONCEPT OF DISTRIBUTED SYSTEMS (EDGE COMPUTING)

The concept of Distributed Systems (Edge Computing) is a framework and a platform for the demonstration centre of a smart factory. It enables local control, optimisation, problem solving and data storage where it is needed, reducing the response time of the overall system and increasing system flexibility. The demonstration was carried out within the platform of the Demonstration Centre of the Lasim smart factory at the Faculty of Mechanical Engineering, University of Ljubljana.

Purpose

The demonstration of the concept of distributed systems is intended to show the more flexible and agile possibilities of operating a smart factory and in particular the usability for small and medium-sized enterprises (SMEs).

Function

The concept of distributed systems is based on multiple nodes in a network, where each node collects local data and makes local decisions, based on the collected data. In this way we achieve the distribution of control to the locations of the production process. Each node has a defined block structure that enables a connection to the process, which is being controlled, (local I/O) and to the other nodes.

Distributed subsystems collect local data from sensors (pallet presence, local process time, etc.) and receive global process data from the global digital twin (order sequence, required assembly operations, etc.). Distributed subsystems (nodes) enable local decision-making with local digital twins and digital agents, as well as the optimisation of local processes, quality control and error handling to be carried out at a local level. This means that the local nodes only send data to the central node when it is needed to optimise the global process. The data is sent between the nodes when it is required by other nodes. For this reason, a communication network based on the OPC UA protocol is established between the nodes, which enables connectivity between different controllers (different platforms) and also provides security, data encryption and authentication of the interconnected elements.

Innovation

The solution is innovative in the sense that distributed nodes (Edge Computing) provide general connectivity (functionality) and shorter response times, since decision-making, local process optimisation, quality checks and error handling are performed locally, without communication delays and without the need for powerful computing power. The nodes are designed in the "Plug and Produce" mode, which enables the modular design of production systems and thus the automatic connection of the node to the production network.

Effects

The effects of the concept of distributed systems are reflected in greater flexibility of the production process, shorter response times of the individual subsystems, shorter delays in communication between the subsystems, more agile error solving in the production process and lower computing power required.
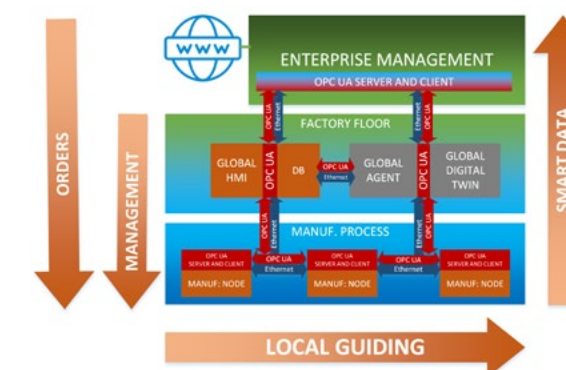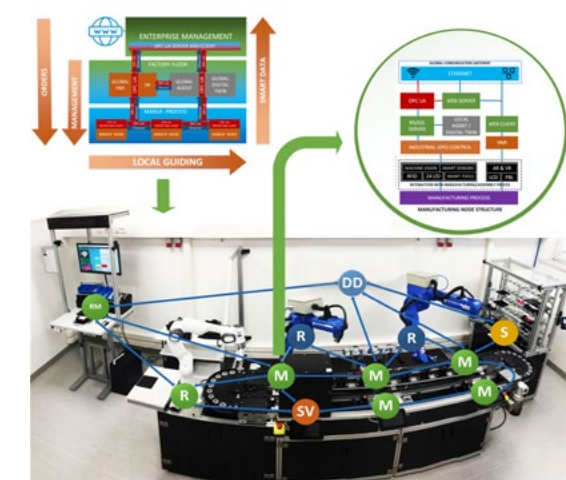
Areas of Application

Production automation, production planning and smart factories.
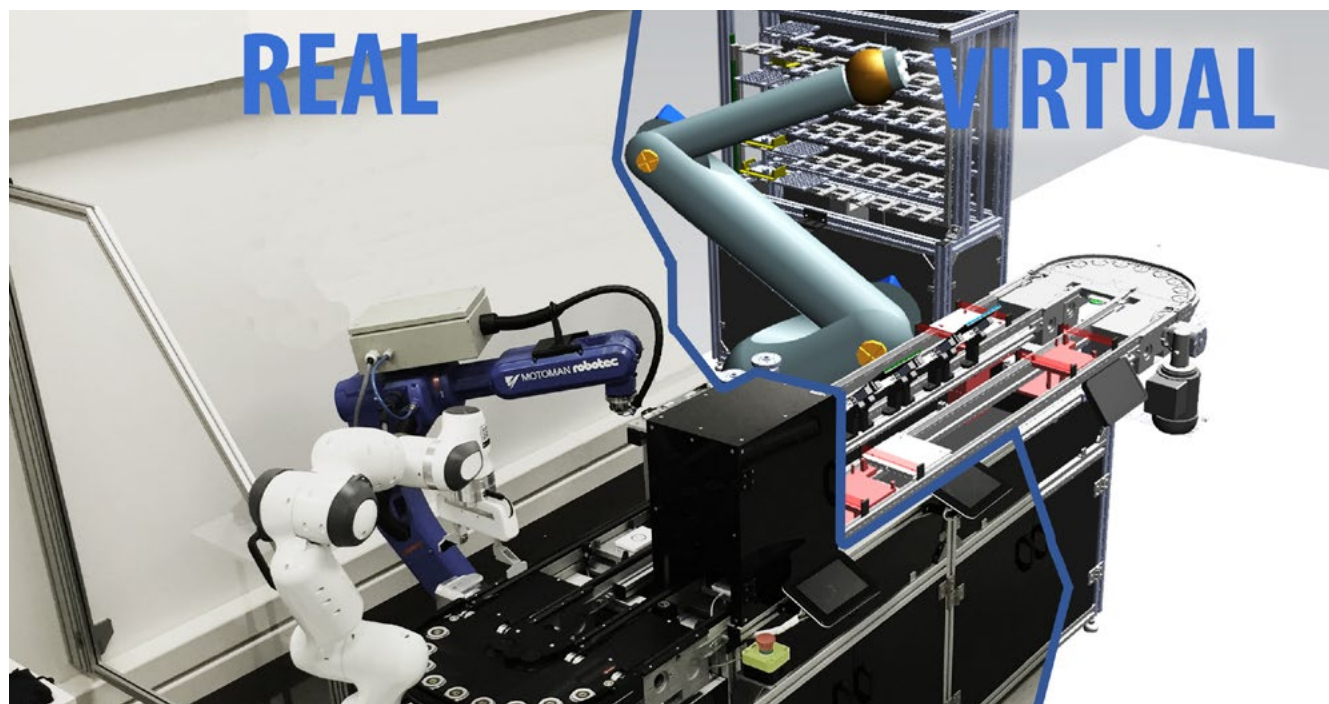
Contributing Partners

- University of Ljubljana, Faculty of Mechanical Engineering (fs.uni-lj.si)

More Information

- Jernej Protner (jernej.protner@fs.uni-lj.si)
- dr. Miha Pipan (miha.pipan@fs.uni-lj.si)
- prof. dr. Niko Herakovič (niko.herakovic@fs.uni-lj.si)

ROBOTICS

DEMONSTRATION OF DIGITAL AGENTS FOR AUTOMATIC OPTIMISATION OF THE PRODUCTION PROCESS

Digital agents in combination with the digital twin allow you to make quick and smart decisions completely automatically. Their task is to get input from the digital twin and based on that provide a quick or best autonomous solution and make the decision for the most optimal continuation of the production process. In this way the digital agents complement digital twins (they replace humans in making decisions) and on the other hand speed up the operation of the digital twins.

Purpose

Increasing the competitiveness of enterprises to a large extent depends on the efficiency of production systems and processes. Their efficiency can be increased with various optimisation methods, especially in terms of reducing costs, shortening lead times, delivery times, increasing equipment utilisation, etc. One of the most effective methods for optimising such systems is an optimisation with an on-line simulation. For this purpose, we have developed an innovative expert system and an on-line simulation methodology, where we upgraded the digital twin with digital agents. This has enabled continuous control and an ongoing optimisation of the real production

system and process without the need for human collaboration in decision-making processes.

Function

Each digital agent has its own job or function. It is the digital agent's job to find a solution and make the decision (with the final solution) quickly and automatically, as soon as it receives a request from the digital twin, and send that solution back to the digital twin. Digital agents communicate directly with the digital twin. Some digital agents also communicate with each other, further accelerating the operation of decision-making and of the digital twin itself. Digital

agents operate completely autonomously from one another but there is also a link between them via a global digital agent. The global digital agent's main task is to coordinate the proper order of operation of all other digital agents.

Innovation

The basic idea of the approach was to develop an expert system of digital twins and digital agents, that was combined with the real production system via the cloud. Through the cloud, the expert system gets all the input data about the production system and the orders (production plan). The expert system then sets an optimal production plan and sends it back to the real production system through the cloud, where the implementation of this production plan begins. The expert system also checks the impact of disturbances occurring in the real system and, if necessary, corrects the production plan in such a way that it eliminates the influence of disturbances or the disturbance itself and sends the data to the real system via the cloud - all in real time.

Effects

By using and developing digital agents with digital twins, we have improved the performance of the real production systems by up to 40%.
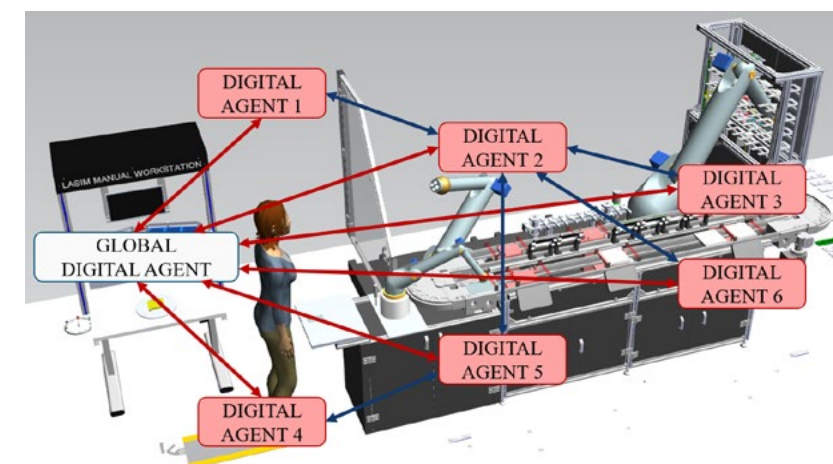

Areas of Application

By creating and continuing to use the digital expert system, the methodology and software tool are defined and designed in a way that enables companies to dynamically plan and direct production activities, shorten their lead times and delivery times, increase the equipment efficiency, etc. All this means that companies reduce waste and increase their competitiveness and profits.

Contributing Partners

- University of Ljubljana, Faculty of Mechanical Engineering (fs.uni-lj.si)
- KOLEKTOR GROUP d.o.o. (www.kolektor.com)

More Information

- prof. dr. Niko Herakovič (niko.herakovic@fs.uni-lj.si)
- dr. Hugo Zupan (hugo.zupan@fs.uni-lj.si)
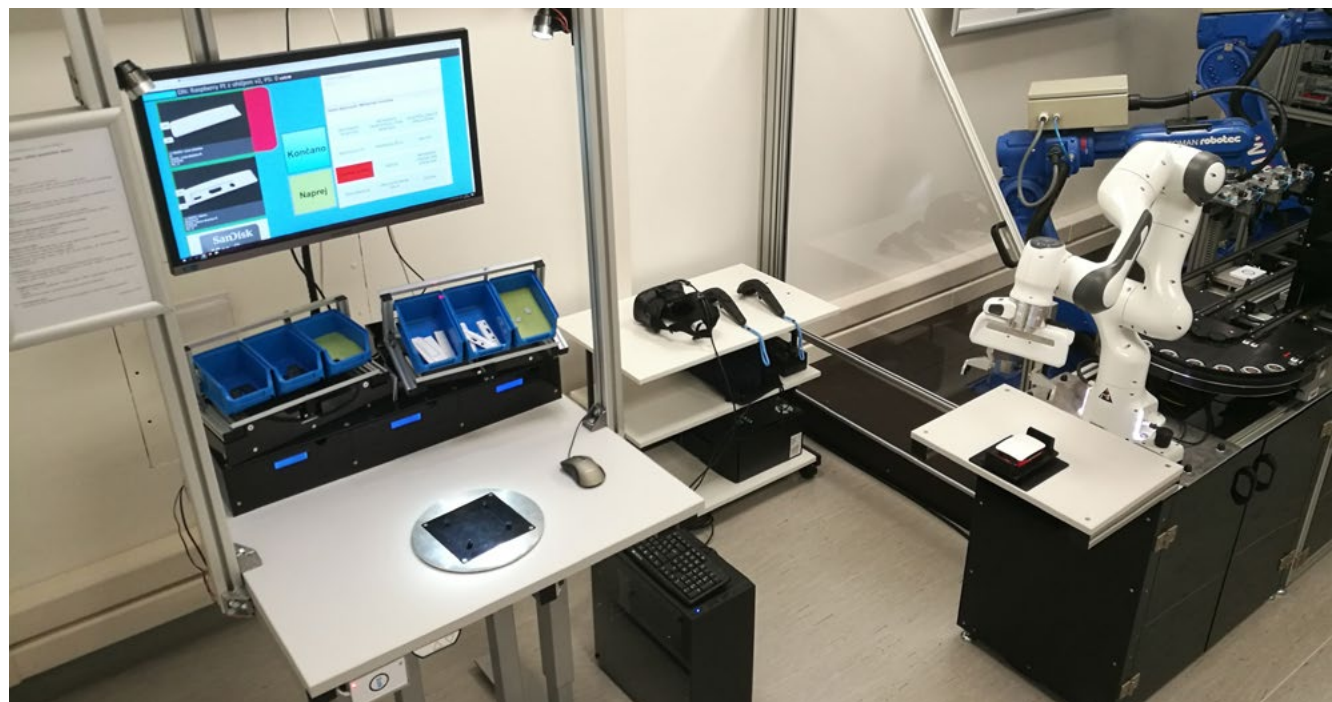
SMART MANUAL ASSEMBLY WORKSTATION WITH A COLLABORATIVE ROBOT

A smart manual workstation, equipped with Industry 4.0 technologies, in collaboration with a collaborative robot (cobot), represents the link between manual and automated manufacturing processes, with an emphasis on safety, ergonomics and increased productivity for the individual worker.

Purpose

The purpose of a smart manual workstation in collaboration with a cobot is to adjust the working environment to the individual worker, by implementing smart technologies, such as visualisation, digitalisation of instructions (developed LPM system in LASIM), error prevention (Poka Yoke), smart lighting and parts delivery, according to the product structure. The collaborative robot is the link between automated and manual production, to ensure greater workers' safety.

Function

In a smart manual workstation, we have implemented a system for displaying assembly instructions (an application for displaying instructions, tracking operations and reporting errors) with smart lights, "pick by light" smart grab containers and a connection with the smart factory database, which guides the worker through assembly operations, depending on their constitution and manual assembly process. When working with a collaborative robot, the worker no longer needs to reach into the automated part of the production, which means there is no need for safety rails/curtains in the area. The smart manual workstation provides an ergonomic working environment and the collaborative robot ensures that larger and heavier parts are transported to the assembly nest.

Innovation

The solution is innovative because it combines smart technologies in a manual workstation, taking into account various influencing parameters, such as assembly process, product structure and human anthropometry, in order to adapt the workstation to the individual worker, according to the principles of ergonomics, and to avoid errors in the assembly processes.

Effects

A smart manual assembly workstation in collaboration with a collaborative robot affects the ergonomics and safety, prevents errors during the assembly process and causes a productivity increase.

Areas of Application

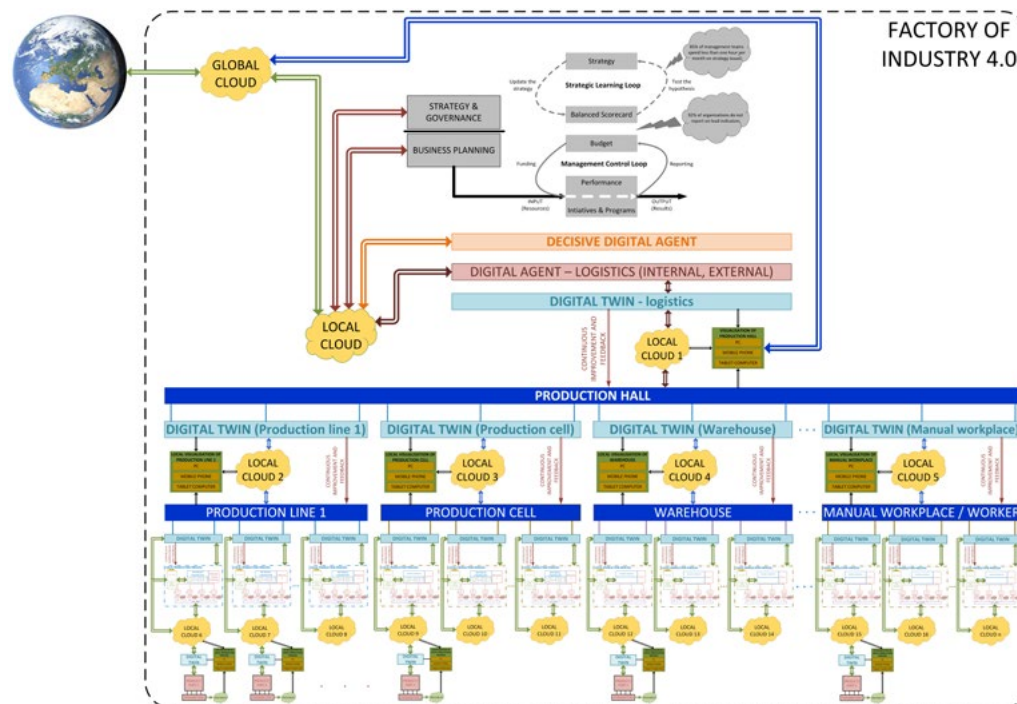Manual assembly and human-robot collaboration.

Contributing Partners

- University of Ljubljana, Faculty of Mechanical Engineering (fs.uni-lj.si)

More Information

- Maja Turk (maja.turk@fs.uni-lj.si)
- dr. Miha Pipan (miha.pipan@fs.uni-lj.si)
- prof. dr. Niko Herakovič (niko.herakovic@fs.uni-lj.si)

ROBOTICS

ARCHITECTURAL MODEL OF A SMART FACTORY LASFA

The LASFA architecture model shows the building blocks of a smart factory, the connections between them and the technologies that make the smart factory operate. The LASFA architecture model provides a framework that facilitates the planning of smart factories.

Purpose

There are many different definitions of a smart factory. There are also many different architectural models but none of them clearly define the links between the building blocks of a smart factory and the technologies required for its smooth operation. LASFA architectural model illustrates the concepts of artificial intelligence and shows the locations of digital twins with digital agents at different levels of the factory. In this case, the digital twin is the backbone of the smart factory.

Function

The LASFA architecture model gives users a clear understanding of Industry 4.0 and smart factories.

The levels of a smart factory (from the production to the enterprise level) are defined within the factory and each level has its own building blocks and characteristics. The LASFA architecture model has the structure of a distributed system, which means that all systems are interconnected. Every subsystem has the ability of self-decision making. Because of that, the system's reactions are faster.

Innovation

The solution is innovative because it clearly shows the construction of a smart factory with all the building blocks. Unlike the Reference Architectural Model Industry 4.0 (RAMI 4.0) the structure of the building blocks is displayed in 2D. This makes the presented architecture model more understandable and easier to use. The innovativeness of the solution is also demonstrated by the fact that the model is applicable regardless of the size of the planned smart factory and regardless of the type of industry that will be carried out in it.

Effects

The effects of the newly-developed smart factory architecture model are reflected in the simpler and faster design of smart factories. In addition, the planning is clearly defined, which means that the user knows what to do within a particular level of planning.

Areas of Application

LASFA smart factory architecture model is used to design smart factories of different sizes and different industries. The model is general and can be used for the following purposes: production automation, smart factory planning design, production scheduling etc. The architectural model can also be used effectively in the transformation of traditional factories into smart factories.
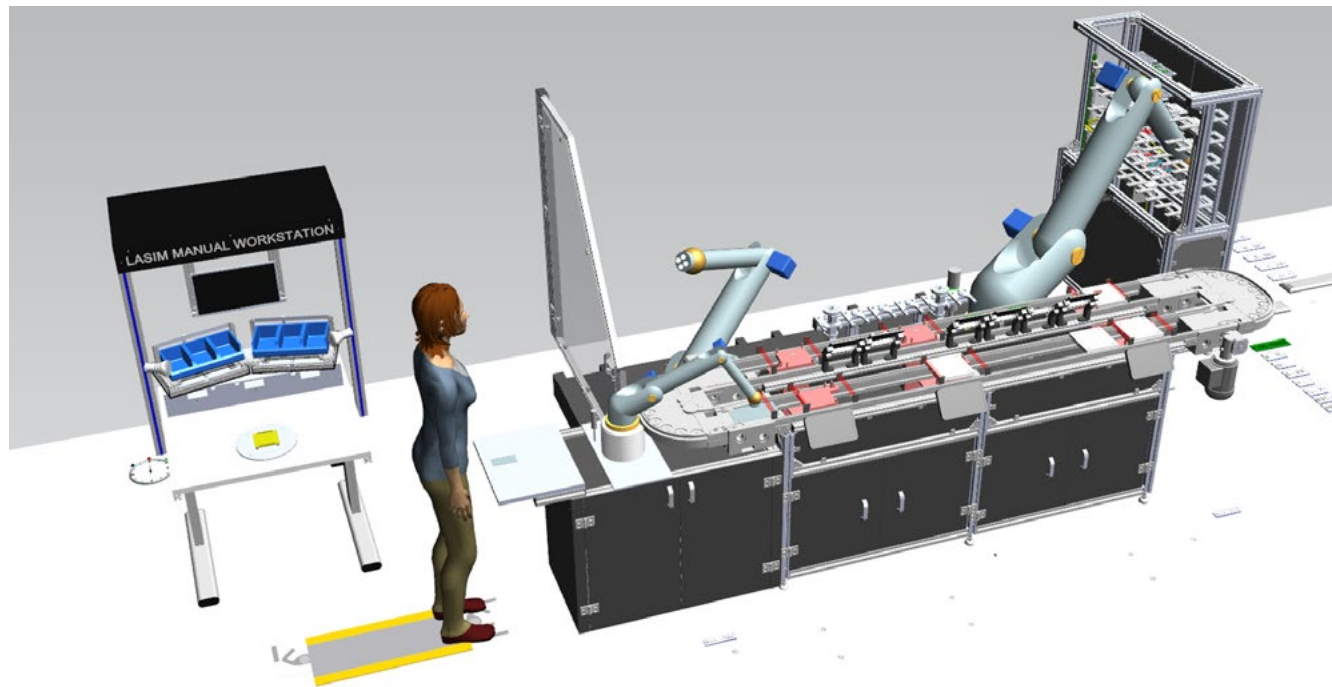
Contributing Partners

· University of Ljubljana, Faculty of Mechanical Engineering (fs.uni-lj.si)

More Information

· Matevž Resman (matevz.resman@fs.uni-lj.si)
· dr. Hugo Zupan (hugo.zupan@fs.uni-lj.si)
· prof. dr. Niko Herakovič (niko.herakovic@fs.uni-lj.si)

ROBOTICS
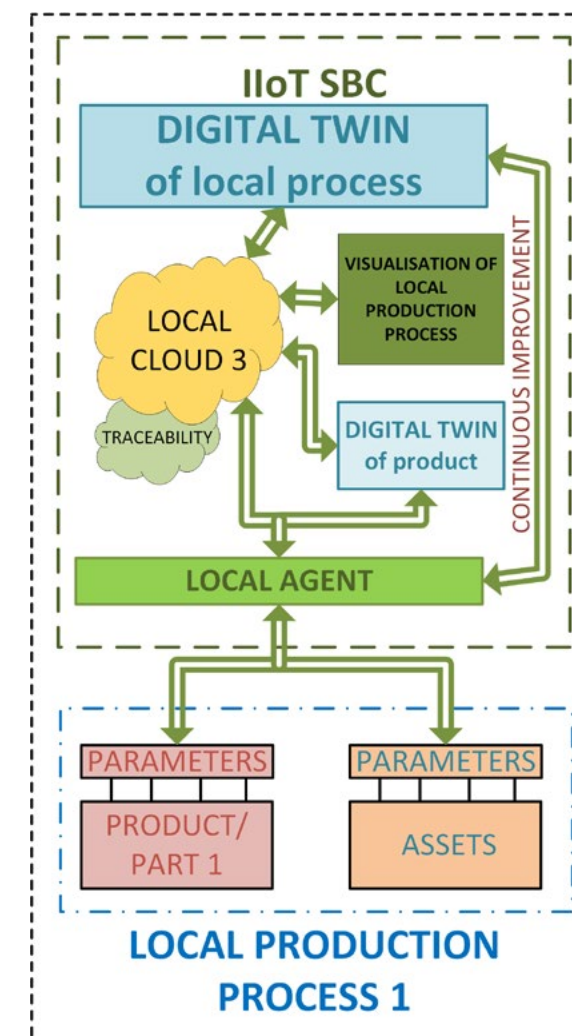
INTRODUCING THE DIGITAL TWIN INTO PRODUCTION SYSTEMS

A digital twin is a detailed virtual copy of a real system and is used for planning and optimising production, for predictable production and also for creating a working plan. The digital twin is an appropriate tool for executing "what-if" scenarios, as we can quickly see how changing the input data, parameters and resources affects the real system.

Purpose

The digital twin represents an upgrade of the simulation model. When designing a production simulation model, data is entered manually, which quickly leads to errors. When using a digital twin, data acquisition from the system is done automatically, so that the possibility of errors is practically eliminated. In addition, the digital twin returns data to the system. With digital twins communication is possible in both directions.

Function

We developed a generalised methodology for collecting the data needed to develop a digital twin.

With the help of this methodology we can quickly define the production line and develop a digital twin with just the absolutely necessary information. The amount of data to be processed is greatly reduced.

Innovation

The solution is innovative because the amount of data to be processed is greatly reduced and it does not allow the input of wrong or unnecessary parameters into the digital production twin. The reliability and speed of digital twin construction is improved. The innovation is also reflected in the approach to the digital twin itself, as we have developed a methodology that defines the parameters required to develop digital twins in different production systems.

Effects

The developed system is used for real-time production planning and allows the work schedule to be changed in case of an unexpected production stop. The effects are also reflected in the design of a smart factory because the optimal layout of the machines can save a lot of space and the associated costs.

Areas of Application

The solution is used in all areas of production automation when it comes to designing smart factories or transforming a traditional factory into a smart factory or to create a production plan. It is useful for large, small, and medium-sized enterprises.

Contributing Partners

· University of Ljubljana, Faculty of Mechanical Engineering (fs.uni-lj.si)
· KOLEKTOR GROUP d.o.o. (www.kolektor.com)

More Information

· Matevž Resman (matevz.resman@fs.uni-lj.si)
· dr. Hugo Zupan (hugo.zupan@fs.uni-lj.si)
· prof. dr. Niko Herakovič (niko.herakovic@fs.uni-lj.si)
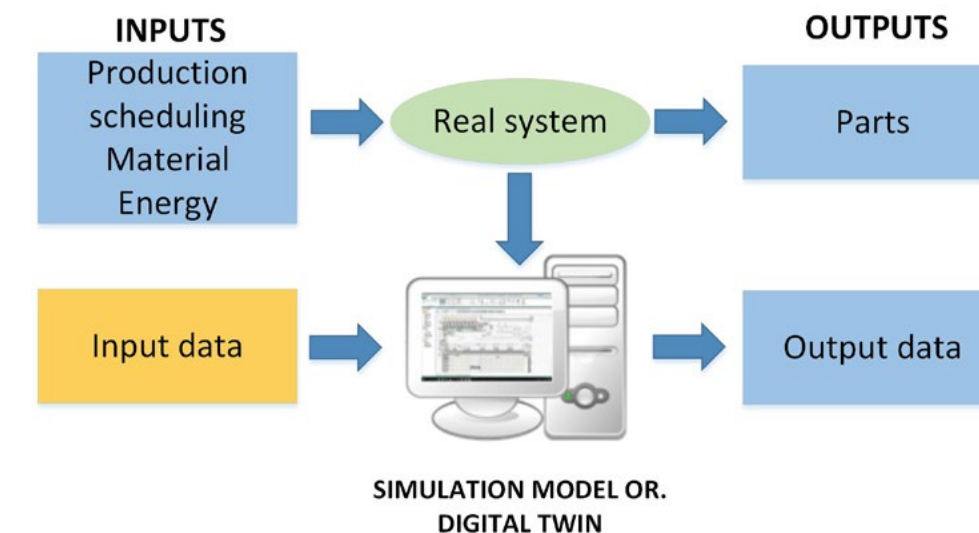
DEMONSTRATION CENTRE SMART FACTORY

The demonstration centre Smart Factory represents a smart factory with all the Industry 4.0 technologies and is one of a kind in Slovenia. It is designed on the basis of the architectural model LASFA and on the concept of distributed systems. The traceability and communication between different assets are implemented with RFID technology.

Purpose

The aim of the demonstration centre Smart Factory is primarily research and development of existing and new Industry 4.0 technologies, students' education and education in general, project work, and providing workshops for industrial partners.

Function

The demonstration centre Smart Factory enables self-operation and self-decision making processes and presents different approaches to integrating all key technologies of the Industry 4.0 for a functional smart factory (product traceability, digital twins, digital agents, machine vision, human-robot collaboration, smart warehouse, smart manual workstation, etc.). In addition, the demonstration centre also includes a smart manual workstation with adjustable table height, adjustable grab containers, "pick by light" technology, adjustable brightness and angle of light beam, etc.

Innovation

The demonstration centre Smart Factory represents the original integration of advanced technologies. The systems are not interconnected into a centralised system but form a distributed net system, which is divided into several subsystems with their own logic (digital twin in collaboration with a local digital agent) and they have the ability to make local decisions and optimise processes locally. Individual subsystems communicate with each other without a constant direct communication with one central node, which leads to reducing delays and difficulties in communication and data transmission. This also increases the system's ability to solve errors quickly. The smart manual assembly workstation is also innovative, since it has adjustable lighting, a height-adjustable workbench and adjustable grab containers based on gender and the worker's constitution.

Effects

The effects of the demonstration centre are reflected in only the minimal and urgent communication with the central node and therefore in faster automatic decision-making at the local level. The demonstration centre is built to allow new technologies to be added and tested in a laboratory environment. The effects of a smart manual workstation are increased work efficiency and better ergonomics for the worker. Because of all of the above, the solution is also interesting from a market point of view.

Areas of Application

The solution is useful in all areas of production and in all industries where we want to increase efficiency of production, automation, logistics, etc. for small and medium-sized enterprises.

Contributing Partners

- University of Ljubljana, Faculty of Mechanical Engineering (fs.uni-lj.si)
- KOLEKTOR GROUP d.o.o. (www.kolektor.com)

More Information

- prof. dr. Niko Herakovič (niko.herakovic@fs.uni-lj.si)
- dr. Hugo Zupan (hugo.zupan@fs.uni-lj.si)
- dr. Miha Pipan (miha.pipan@fs.uni-lj.si)
- Jernej Protner (jernej.protner@fs.uni-lj.si)

DEMONSTRATION OF INTELLIGENT PRODUCTION PLANNING

Artificial intelligence is one of the key enabling technologies of Industry 4.0.
The demonstrated Qlector LEAP platform is an AI (Artificial intelligence) based tool for a more efficient optimisation of production and business processes, production scheduling and analysis.

Purpose

Production scheduling and intelligent planning, more accurate and stable forecasts (orders and realisation, supply chain, human resources...), anomaly detection and route-cause analysis for standstills with intelligent alerting.

Function

Insight into the current state of the factory via link to the production and business systems (ERP, MES, PLC, IoT) with real-time anomaly detection and alarming. Intelligent planning provides comprehensive insight into the realisation and prediction of work orders. Additional scenarios include aligned multiple-tool change, inventory monitoring (usage forecast, pro-

curement planning) and forecast of delayed /finished early work orders.

Innovation

With the "Platform of the virtual factory" we have demonstrated an innovative approach to scheduling and monitoring of the factory with the solution based on artificial intelligence.

We have successfully introduced a new paradigm in the field of production planning, based on the statistical digital twin (historical data) and the production capacity model.

Innovative features of the platform are also modularity, automated learning from the historical data,

knowledge graph for the structuring of the production data model and what-if analysis to understand the potential effects of resource availability and other changes to the production plan realisation.

Effects

- Time savings for managers and production planners
- Transparent and automated information transfer with insightful data visualisation
- Identification of trends and anomalies of planned and unplanned stops, cycle speed and scrap
- Enabling predictions and reactions to incidents before they can affect the production plan and analysis of the impact of each incident to OEE and other KPIs
- Optimised production plans, by taking into account past performance to reduce downtime and increase production capacity

Areas of Application

Monitoring and production scheduling in various industries, where companies are facing problems of increased inventory, longer production cycles and long delivery of raw material, inaccurate demand forecasts, unrealistic norms for production plans, inefficient information transfer ...
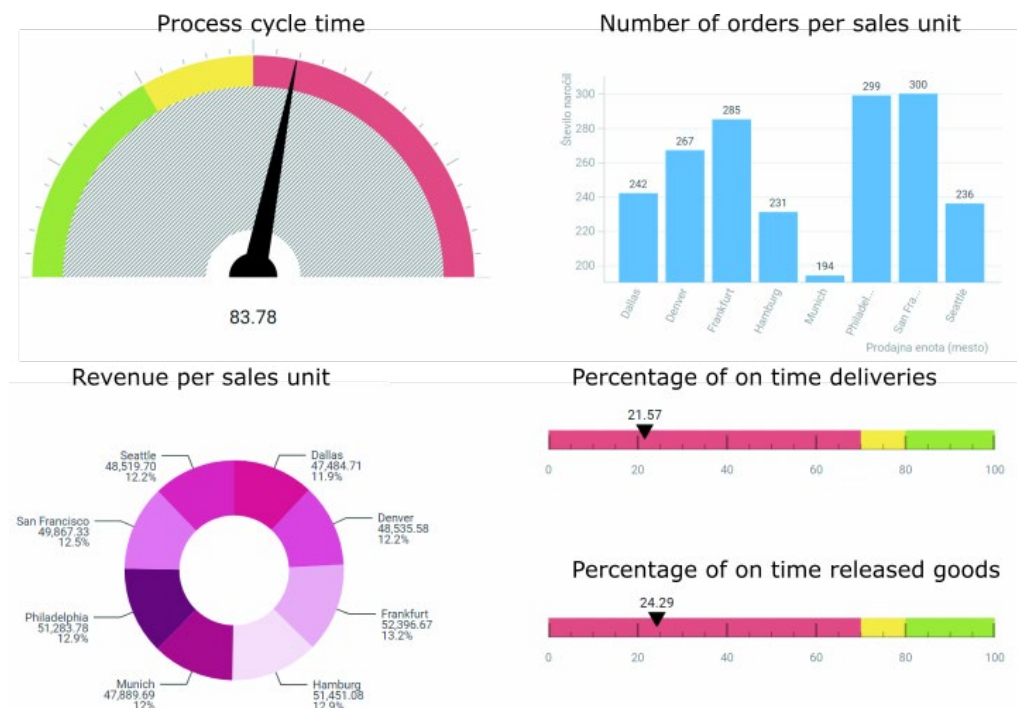
Contributing Partners

- KOLEKTOR GROUP d.o.o. (www.kolektor.com) with the company Qlector d.o.o. (www.qlector.com)

More Information

- Nejc Lisac (nejc.lisac@kolektor.com)
- Aleš Gajšek (ales.gajsek@kolektor.com)
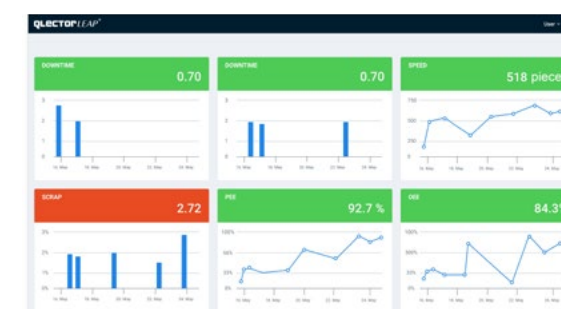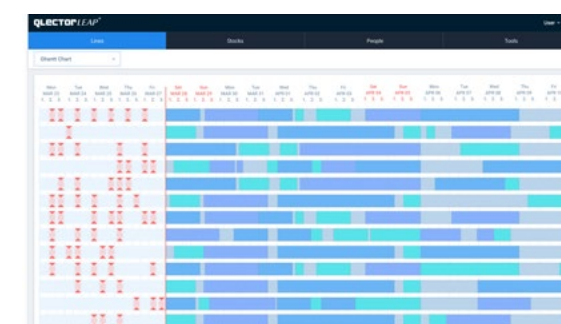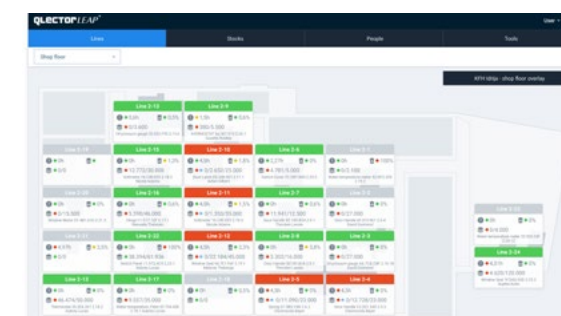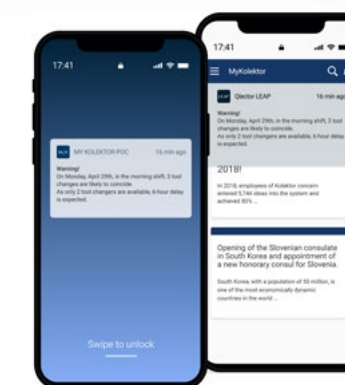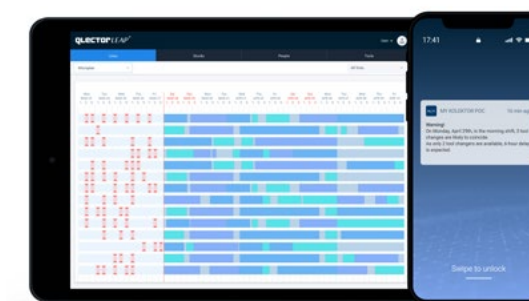
A PERSONALISED DASHBOARD FOR THE DISPLAY OF KEY PROCESS PERFORMANCE INDICATORS

Key information in the right format, at the right time, in the right place!

Purpose

Company executives, along with their process administrators, make decisions based on available information and their previous experience. Key process information is often found in various information systems that are not interconnected or available in a user-friendly format. However, accessing and processing information in such a format can be time-consuming and error-prone. For these reasons the implementation of an umbrella tool that delivers crucial personalised information to the user in near real-time in a simple, understandable and accessible way may significantly improve the efficiency of company employees.

Function

The ARIS platform process mining tools use data from information systems like SAP to provide the end user with key information, regarding the process state and results and the environment, in which the process is performed. In addition to performance indicators, ARIS constantly performs and displays preset analyses and process flows, that further improve the understanding of the information provided. Additionally, the system allows an automatic search of the root causes of the displayed process results.

Innovation

The implemented system uses state-of-the-art process mining technology, which differs from previous methods in that it is more autonomous, enables monitoring of processes through multiple information systems, takes place in near real-time and allows for the use of process mining results to design improved processes. This type of system enables the integration of artificial intelligence tools and is useful for the support of variable processes, such as robot-aided reconfiguration.

Effects

System users have access to key process performance information all in one place, which allows for easier decision making, saves time and improves work efficiency.

Areas of Application

The system was validated on real examples in collaboration with Kolektor Group d.o.o. but it can be installed and utilised in any company whose processes are supported by IT systems, that store the vital data.

Contributing Partners

· Jožef Stefan Institute – Department for Automation, Biocybernetics and Robotics (www.ijs.si)
· KOLEKTOR GROUP d.o.o. (www.kolektor.com)

More Information

· Jaka Jereb (jaka.jereb@ijs.si)
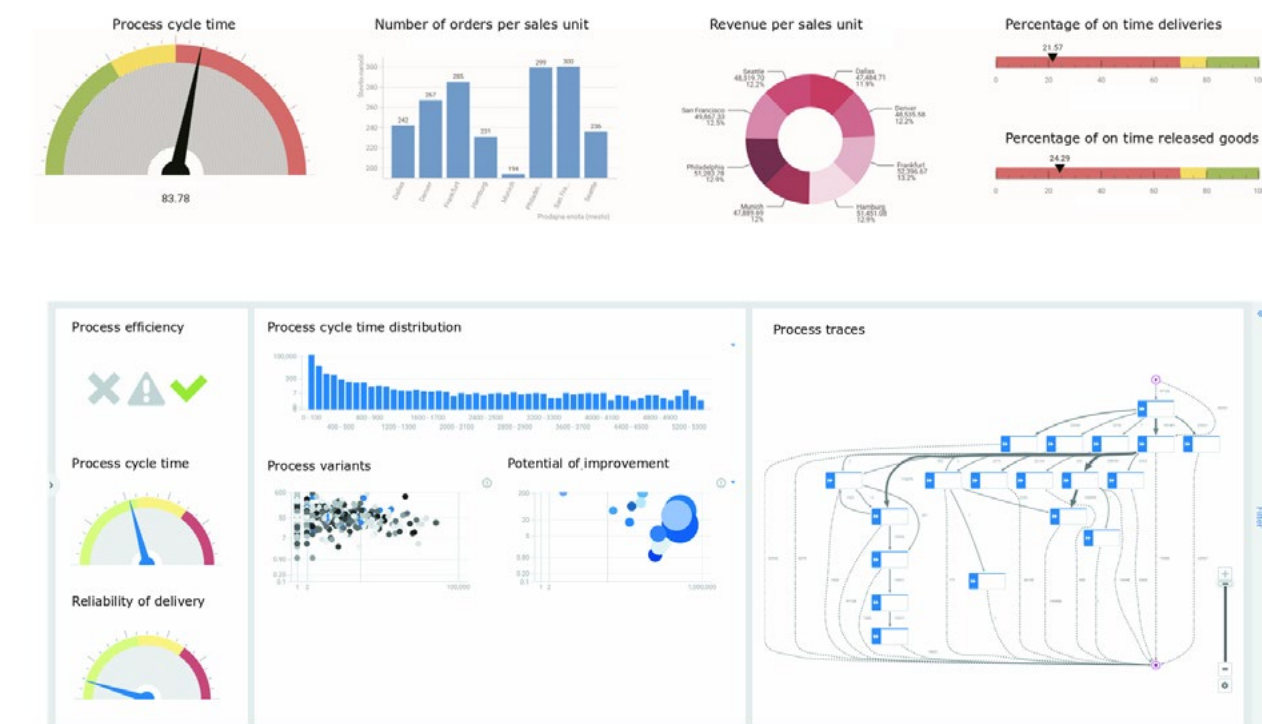
ADAPTIVE ROBOTIC CELL

A modular approach to the automation of statistical process measurements.

Purpose

In order to guarantee the right quality of products, it is necessary to regularly and consistently check various parameters of the products manufactured on the production line. Besides quality control, the optimisation of the manufacturing process is crucial. Due to the unsuitable dimensions of the manufactured products, one can directly or indirectly conclude that there are problems in production, such as wear of milling blades, improperly adjusted injection machines, etc. The current process and quality control system is largely based on manual measurements, performed by the operating personnel with a wide range of gages, measuring accessories and measuring methods.

Function

The robotic cell enables the automation of statistical process measurements. By automating measurements, the influence of the operator can be significantly reduced or eliminated. Furthermore, the number of measuring systems is reduced to four. The current configuration includes key components of Industry 4.0, as it allows a wide range of dimensional measurements for a variety of products and is also modular and reconfigurable.

Innovation

The modular design allows for individual units to be positioned optionally, relative to the central table with the robot, all according to the set of required measurements. The tasks of the robot are defined modularly and according to the local coordinate system of subunits/tables. Due to the great variety of product dimensions and numerous designs, a system for automatic finger exchange was developed. The individual fingers are designed for optimal gripping of a selected number of relatively geometrical-

ly or dimensionally similar products. Unused fingers, golden parts and fixtures are stored in a storage area in the middle of the table, where they are protected from environmental influences, such as light, dust and humidity.

Effects

Based on the selected number of samples taken from the production process, the system follows the control plan, according to the definitions written in the operation sheets of the products. The measured values are stored locally, but are also accessible to higher users and cloud services. Larger deviations and gradual deviations of measured data from the set value are a good indicator for further decisions on necessary changes in the settings of the process itself (machine tools, injection molding machines, etc.) and decisions at the management level.
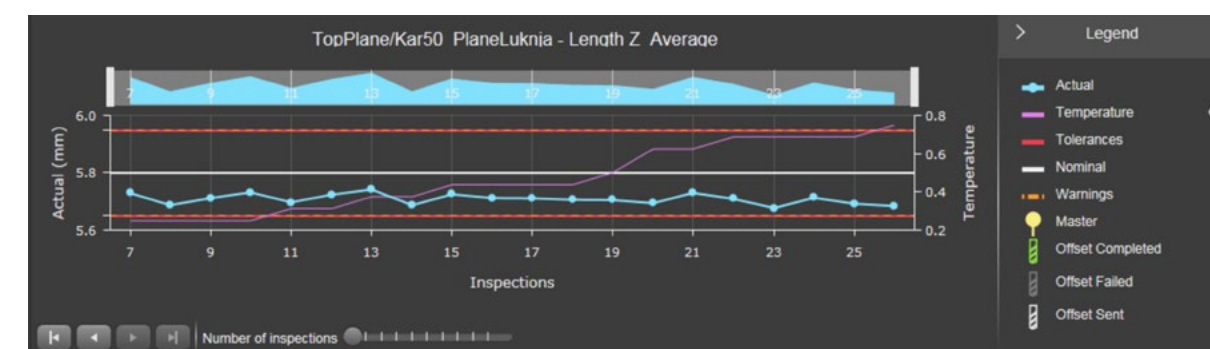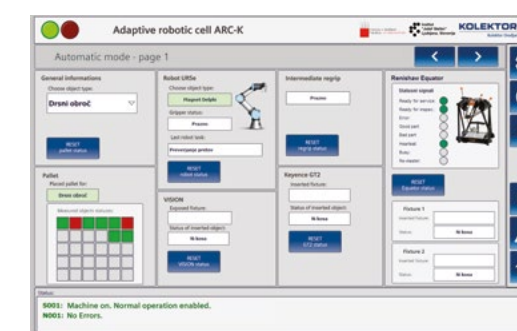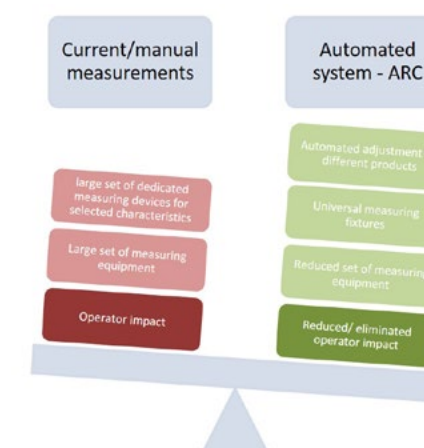
Areas of Application

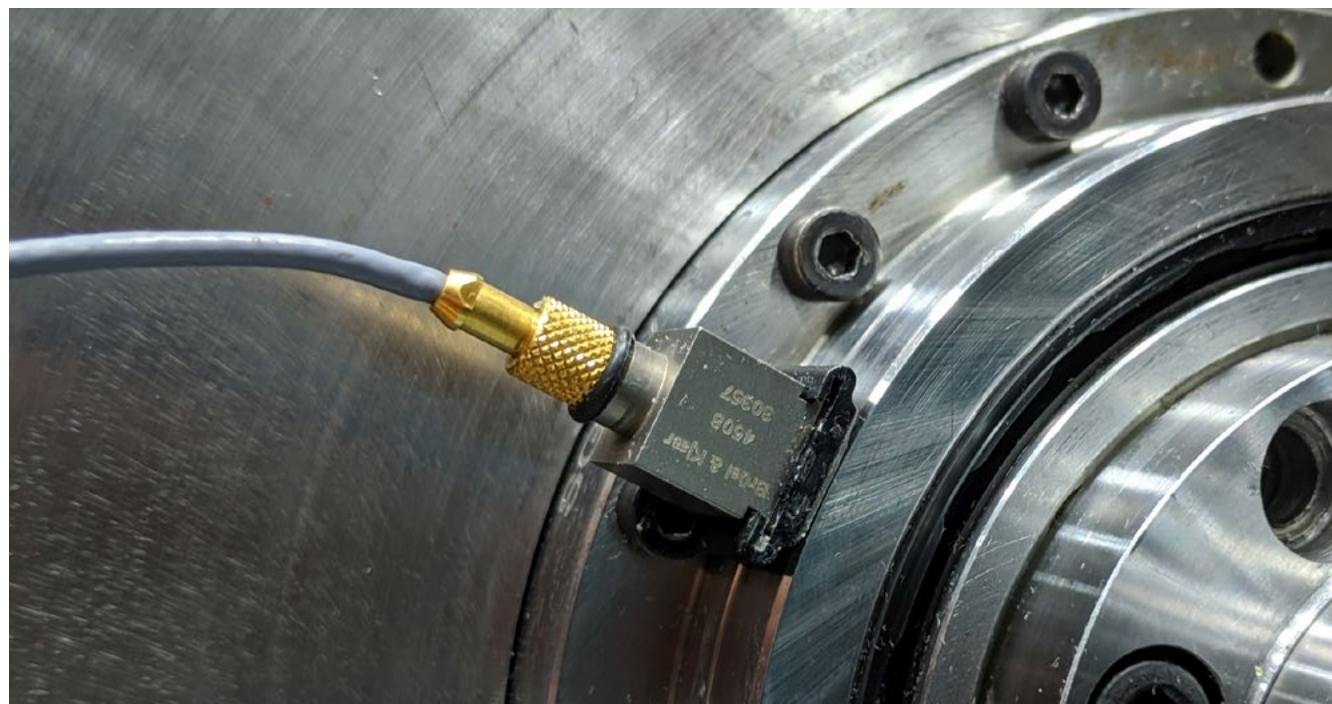Manufacturing processes, Statistical Process Control – SPC.

Contributing Partners

- KOLEKTOR GROUP d.o.o. (www.kolektor.com)
- University of Ljubljana, Faculty of Electrical Engineering (www.robolab.si)
- Jožef Stefan Institute (www.ijs.si)

More Information

- Robert Čerin (robert.cerin@kolektor.com)
- Marko Munih (marko.munih@fe.uni-lj.si)

ROBOTICS

INTELLIGENT MOTOR DRIVE WITH PERFORMANCE MONITORING

Intelligent robotic systems are increasingly used as essential parts of modern technological processes. The developed intelligent drive assembly with motor operation monitoring is the main pillar of these systems and it ensures the reliability and the accuracy of the robot arm operation.

Purpose

Reliable and accurate manipulation and positioning of applications in robotics require the use of a precision intelligent actuator, which is properly controlled by the closed-loop control system. Excessive clearances in the electric motor and the powertrain could result in tool and gripper positioning errors and incur additional costs.

Innovation

The developed intelligent system is representing a set of a servomotor and a closed-loop control system, which successfully compensates the errors of motor control and the entire drive with real-time control of the encoder position. The presented servomotor is an optimal option in terms of dimensions and is properly integrated with the gearbox drive.

Function

The developed drivetrain effectively and precisely controls the electric motor and monitors the parameters at all operating conditions.

Effects

The developed powertrain is an alternative drive, that can be offered to the established robot manufacturers.

Areas of Application

The intelligent powertrain is suitable for use in robotics, automation, mobility, mechatronic systems, biocybernetics, the automotive industry and beyond.

Contributing Partners

- Podkrižnik d.o.o. (www.podkriznik.si)
- Nela d.o.o. (www.nela.si)
- Jožef Stefan Institute – Department of Automation, Biocybernetics and Robotics (www.ijs.si/ijsw/E1/E1%20slo)
- Jožef Stefan Institute – Department of Systems and Control (www.ijs.si/ijsw/E2)

More Information

- dr. Simon Kulovec (simon.kulovec@podkriznik.si)
- mag. Andrej Biček (andrej.bicek@domel.com)
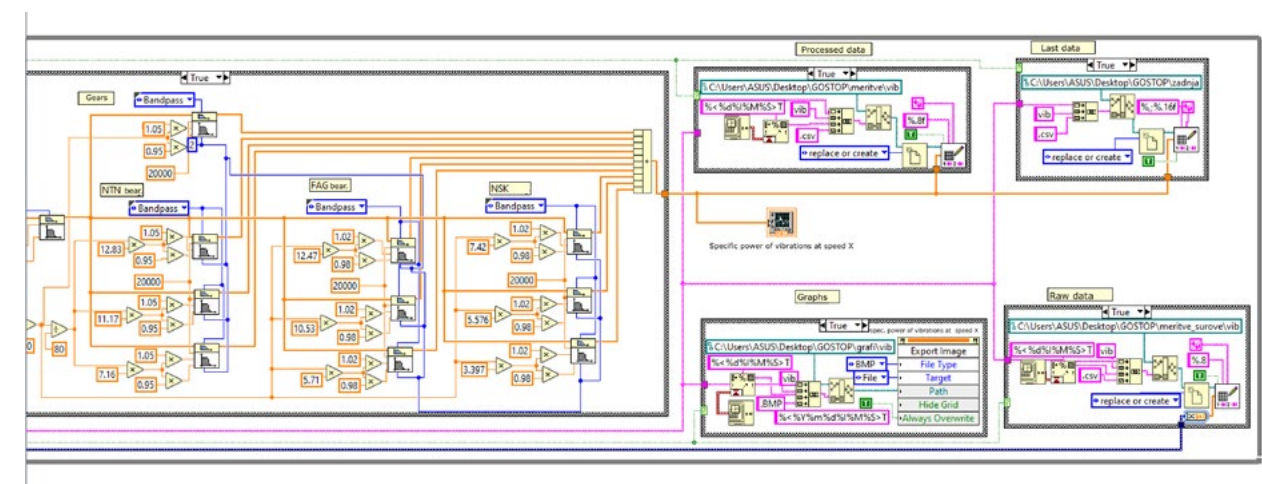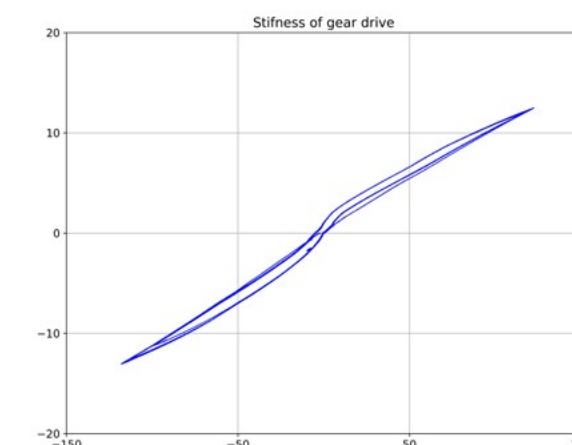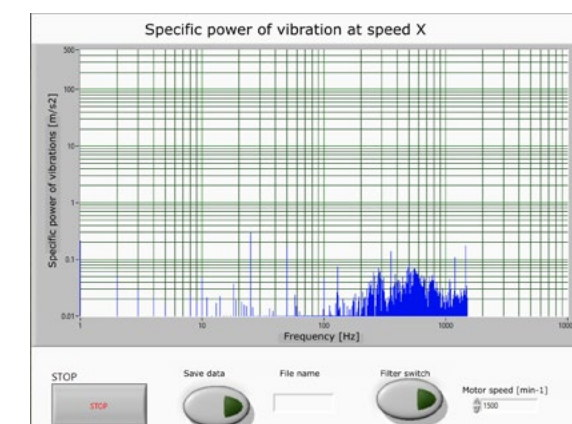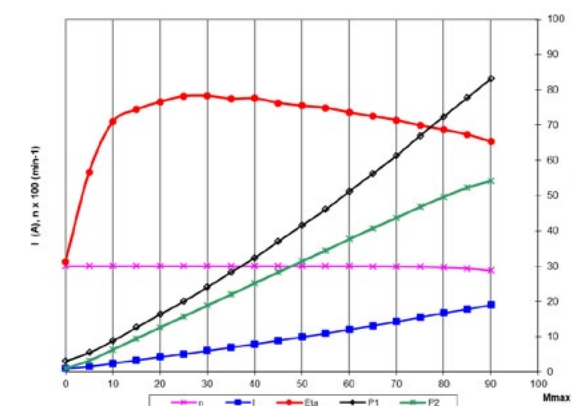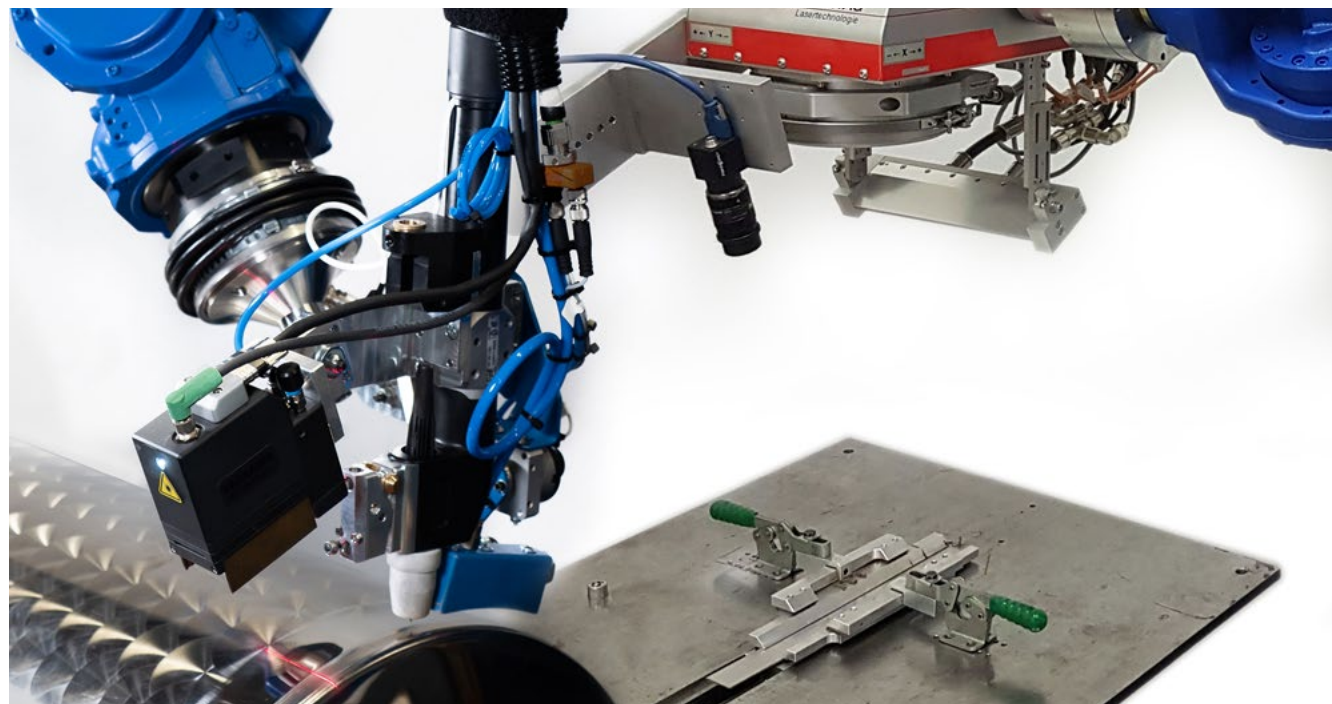
MOTOSense PLATFORM FOR ADAPTIVE CONTROL OF ROBOTIC MACHINING USING LASER TRIANGULATION

The developed laser system enables precise and flexible control of robotic machining, making the technology suitable for production of small-series and customised products.

Purpose

In a small-scale and customised production, the use of robotic machining is traditionally limited by a time-consuming and insufficiently precise programming of the robotic machining path. A particular challenge is the robotic laser processing of small-scale pieces, where the required precision exceeds the ability of visual programming. Furthermore, products made of increasingly thinner metal sheets increase the demand for complex and expensive clamping devices.

Function

The MOTOSense platform incorporates a laser triangulation feedback loop, which enables the measurement of a 3D workpiece shape before machining, in-process adaptation of robot trajectory and other machining parameters and the 3D control of the shape after machining. This enables complete adaptation to each workpiece and 100% quality control of the process.

Innovation

The developed system represents a novel solution in the world market in the field of machining small-scale products of complex 3D shapes. The solution is protected by an international patent, which is in the process of being granted (WO2017017054 A1).

Effects

The developed technology enables 100% process quality control.
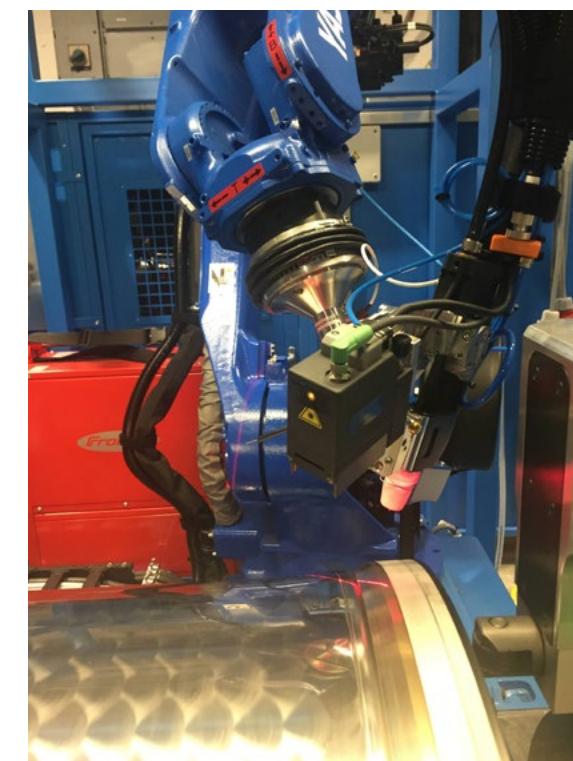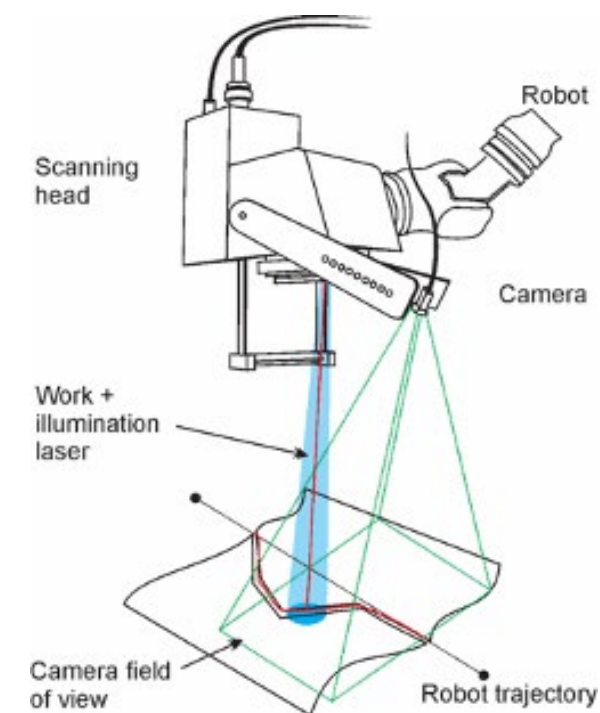
Areas of Application

Robotic welding, laser processing, grinding, deburring.

Contributing Partners

- University of Ljubljana, Faculty of Mechanical Engineering (fs.uni-lj.si)
- YASKAWA Slovenija d.o.o. (www.yaskawa.si)

More information

- Erih Arko (erih.arko@yaskawa.eu.com)

MODULAR SOFTWARE PLATFORM FOR OPTICAL INSPECTION OF PRODUCTS

Machine vision is one of the key enabling technologies of Industry 4.0. The developed software platform is a tool to address the challenges of automating quality inspection processes more effectively.

Purpose

For automatic, contactless, optical quality inspection of products, semi-finished products and raw materials.

Function

The software platform contains components for capturing one- or multi-modal image data and the methods for evaluating image information. The methods are suitable for detecting defects on the surfaces of semi-finished or finished products. The platform also enables the monitoring of the quality of production processes.

Innovation

We have developed advanced defect detection methods, based on deep learning approaches. In doing so, we have introduced a new paradigm in machine vision, based on more generalised data-driven problem-solving methods and supervised deep learning. The ability of these new methods on the selected samples is better than the currently known state-of-the-art solutions. They are useful on both, homogeneous and non-homogeneous, structured surfaces, which cannot be achieved by conventional machine vision methods. Modularity and flexibility are also important features of the platform.

Effects

The software platform is an integral part of software solutions in optical inspection machines, manufactured by Kolektor.

Areas of Application

Optical quality inspection and process monitoring in various industries. Process automation, elimination of unskilled jobs, repeatable and objective decision-making, in a continuous mode of operation, even in environments that are very burdensome for humans.

Contributing Partners

- KOLEKTOR GROUP d.o.o. (www.kolektorvision.com)
- University of Ljubljana, Faculty of Computer and Information Science, Visual Cognitive Systems Laboratory (www.fri.uni-lj.si)
- University of Ljubljana, Faculty of Electrical Engineering, Laboratory for Machine Intelligence (www.fe.uni-lj.si)

More information

- Jure Skvarč (jure.skvarc@kolektor.com)
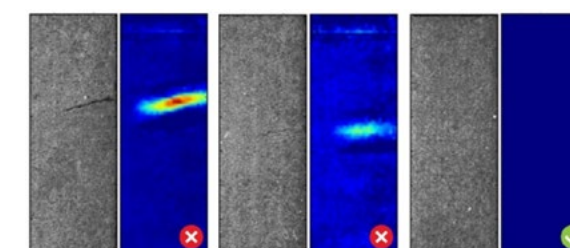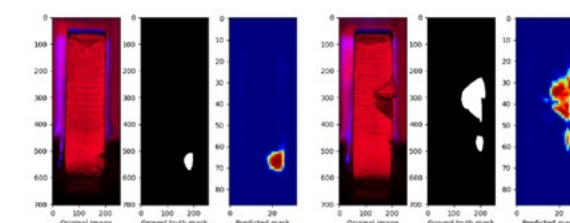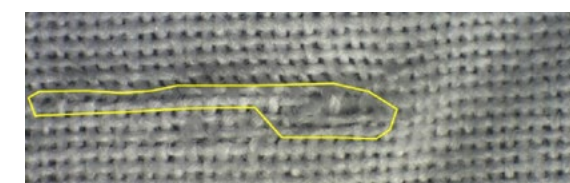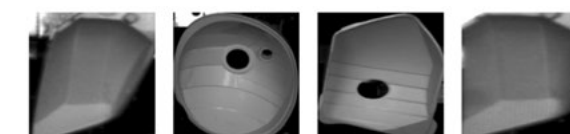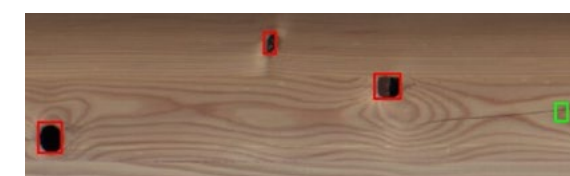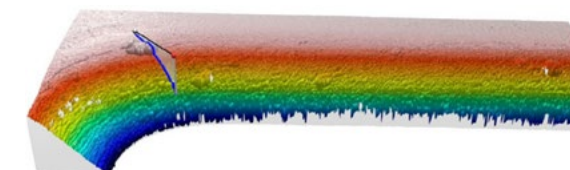
SOFTWARE PLATFORM FOR CONTROLLING ROBOTIC MANIPULATORS WITHOUT DEDICATED PROGRAMMING

The developed software platform enables the user to integrate robotic manipulators faster, as well as fast programming and high flexibility of manipulations for a continuous and discrete quality inspection of end-user products.

Purpose

Classical programming of robots for product quality inspection is a lengthy process, usually performed by specialists. Any and all further modifications of the robotic tasks are therefore time-consuming and expensive. The developed platform simplifies and speeds up the process of integration of robotic manipulators into the industrial environment.

Function

Manual programming of robot trajectories requires the definition of points, transitions between them and the timing of a certain movement. In the environment we developed, the operator selects the scan points on the CAD outline of the product, from which the system automatically generates the desired scan path and determines the most appropriate time correlation of robot motion with the set requirements, using an optimisation algorithm. It is suitable for integration with larger industrial robots, as well as collaborative robots in a shared workspace with humans.

Innovation

The developed system uses advanced robotic path-planning algorithms and machine learning methods to adapt the speed of the execution of robot movements. With it we enable possible variations of the type of manipulated product and/or application, as well as the micro and macro properties of the product. Implementation reduces the time required to perform quality control and consequently, the production capacity.

Effects

The software platform is an integral part of the software solutions for the implementation of robotic manipulators in the industrial environment and in quality control machines, manufactured by Kolektor.

Areas of Application

Quality control in an industrial environment, control of processes for image acquisition with machine vision systems, controlling robotic manipulators in a feedback loop with optical control in various industries.
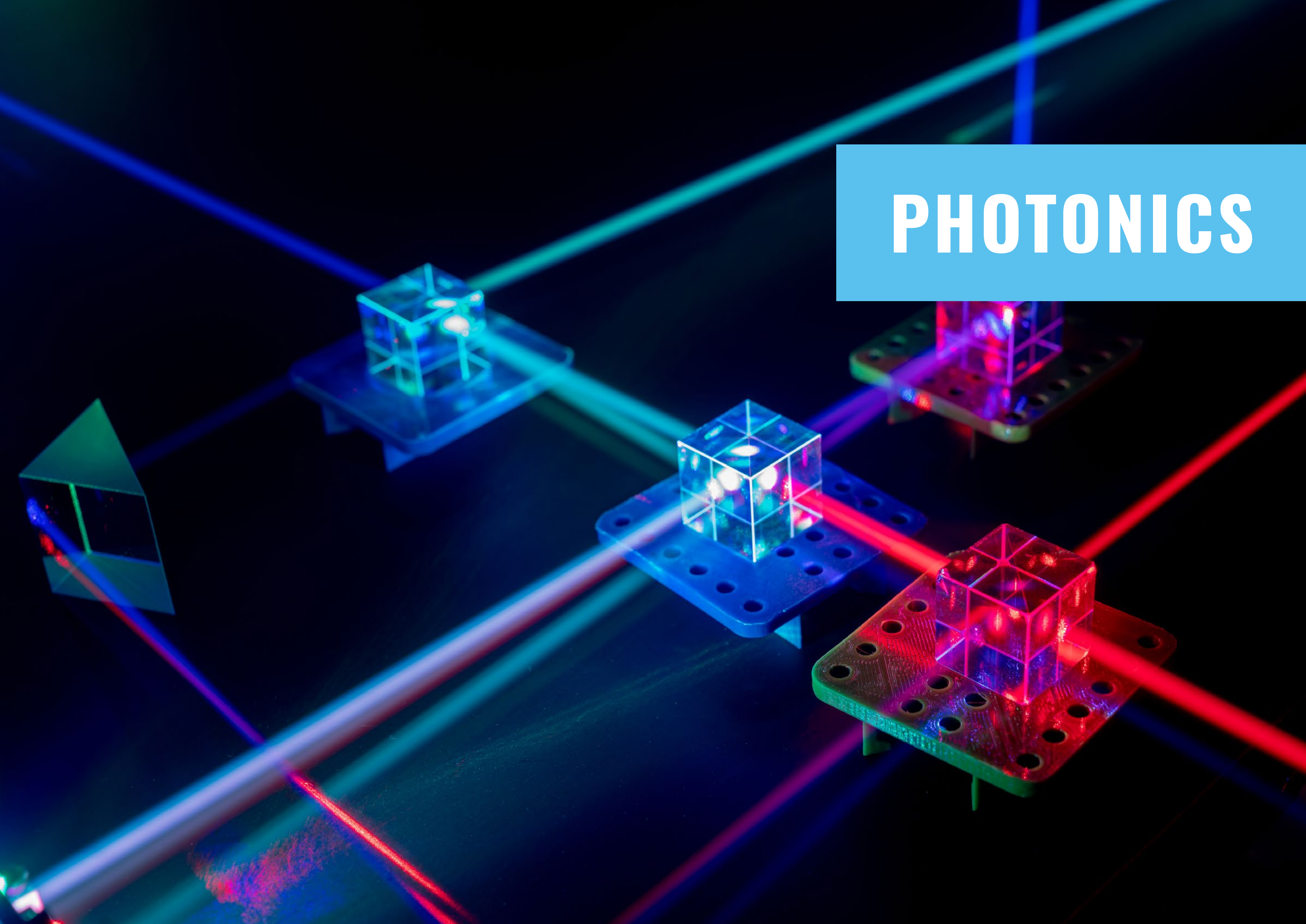
Contributing Partners

- KOLEKTOR GROUP d.o.o. (www.kolektorvision.com)
- Jožef Stefan Institute – Department for Automation, Biocybernetics and Robotics (www.ijs.si)
- University of Ljubljana, Faculty of Electrical Engineering, Laboratory for Machine Intelligence (www.fe.uni-lj.si)

More information

- Jure Skvarč (jure.skvarc@kolektor.com)
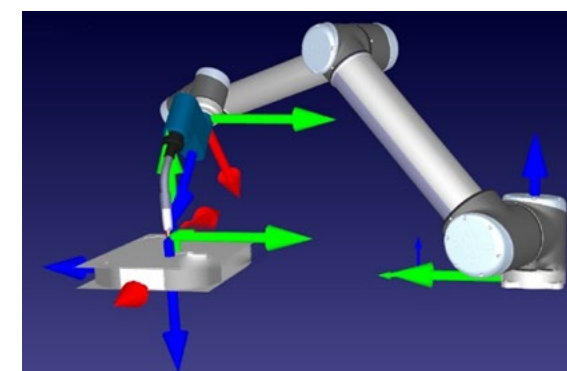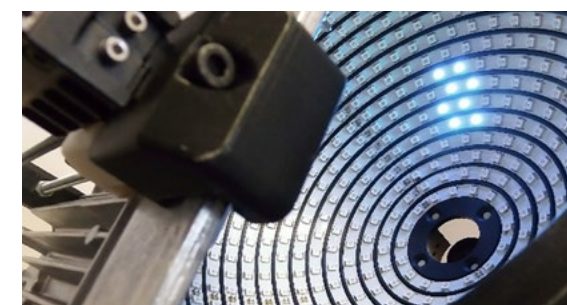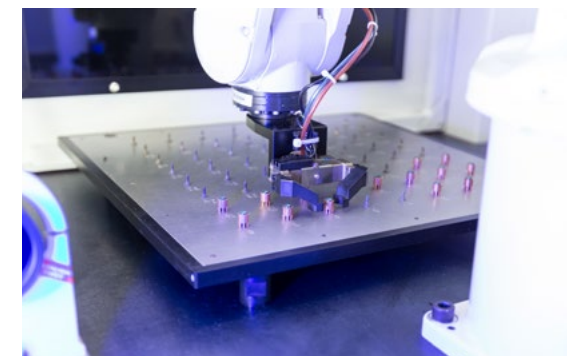
SUBNANOSECOND MOPA LASER SYSTEM

The subnanosecond MOPA laser system generates high peak power laser shocks and is excellent for removing pigment lesions and rejuvenating the skin.

Purpose

The project goal was to develop a reliable sub-nanosecond laser source with an extremely high peak power, operating at a wavelength of 1064 nm, and at the same time to develop all associated parts of the device (e.g. applicators, graphical user interface, etc.), that allow efficient and easy treatment of target lesions.

Function

A sub-nanosecond MOPA laser system was investigated and developed. The laser source was designed as a master oscillator (MO), which produces a short and low-energy laser pulse. The energy is amplified in a sequential power amplifier (PA).

Innovation

The developed laser is characterised by an exceptional high peak power of the laser pulse, the highest of all similar devices on the market. Despite the exceptional peak power, the innovative optical path design ensures long-lasting performance without possibility of damaging internal optical components. The laser is distinguished by special families of applicators, that, with the help of DOE technology, provide completely uniform profiles of the working light beam in the case of full-spot applicators or an extremely uniform peak power of individual points in fractional profiles. A very advanced, yet easy-to-use, graphical interface has been developed for the laser device. The laser device is the smallest on the market. The size resulting from an innovative component design represents an advantage in key markets. All the features make target treatments extremely effective, enjoyable and easy for users to handle.

Effects

Sub-nanosecond pulse has extremely high peak power, namely 2.7 GW, which is about eight times the power of similar nanosecond lasers. With exceptional peak power, it is possible to remove various pigment lesions in the skin more effectively than with a nanosecond laser pulse. The removal can be further enhanced with the application of the two-step FracTat protocol, in which the skin is first microporated with a fractional applicator and then treated with a full-spot applicator. The laser is suitable for treatment of pigment lesions and for rejuvenation treatments.

Areas of Application

The laser device is used in the beauty and rejuvenation industry.
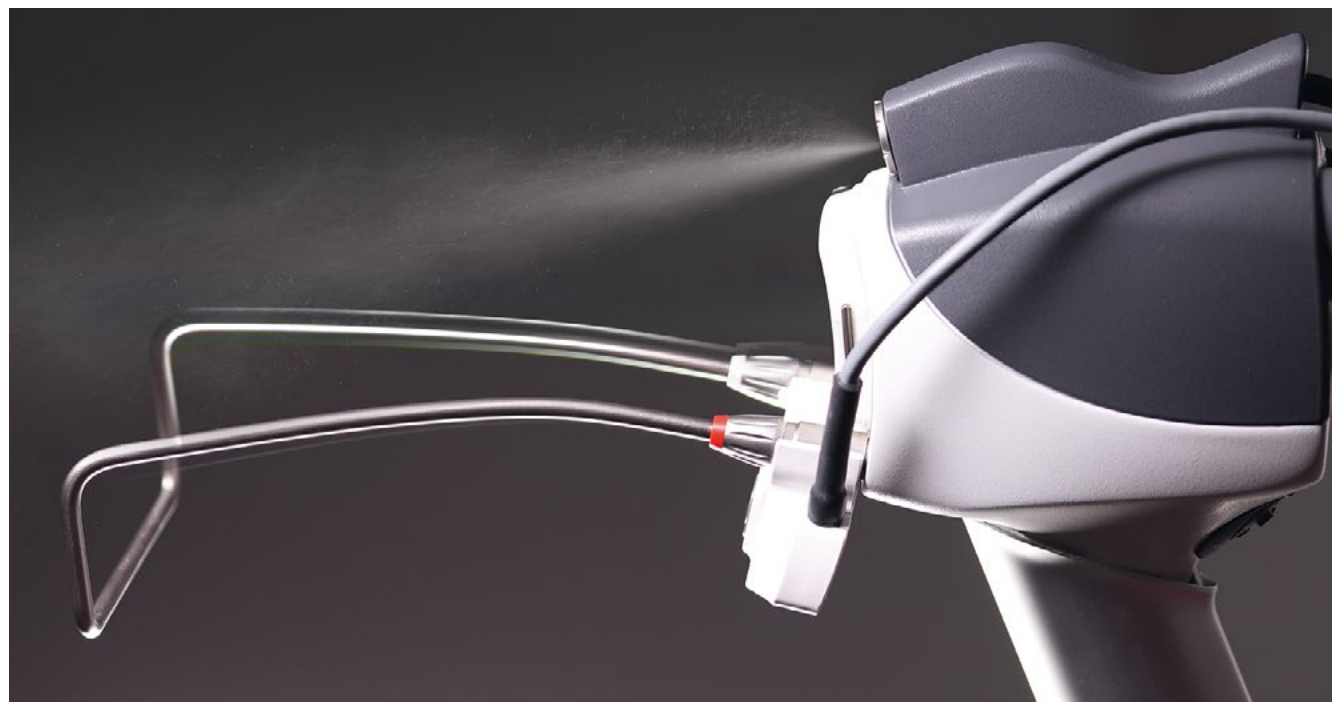
Contributing Partners

- Fotona d.o.o. (www.fotona.com)
- Jožef Stefan Institute (www.ijs.si)
- Optotek d.o.o. (www.optotek-medical.com)
- University of Ljubljana, Faculty of Mechanical Engineering (fs.uni-lj.si)
- LPKF d.o.o. (www.lpkf.com)
- Nela d.o.o. (www.nela.si)

More Information

- Dejan Škrabelj (dejan.skrabelj@fotona.com)

PHOTONICS
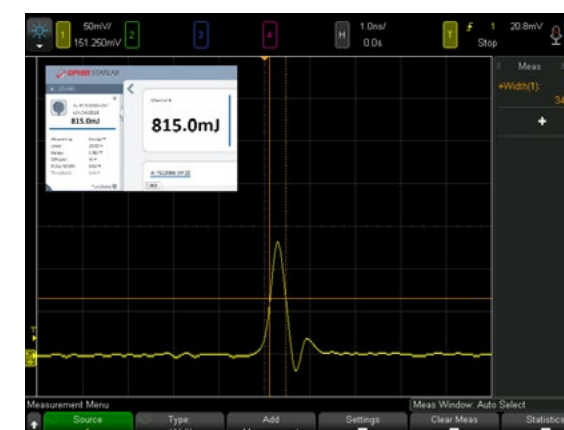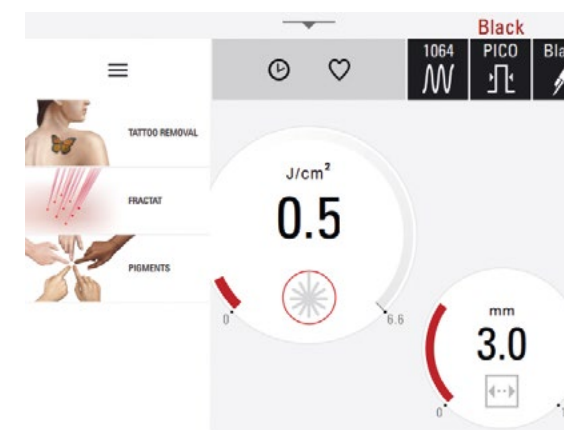
ALEXANDRITE LASER WITH ILOOP SCANNING SYSTEM

The developed laser system enables accurate and effective medical dermatological procedures, based on the integration of innovative optical and sensor solutions.

Purpose

Most laser medical procedures are based on the thermal excitation of the target tissue, so controlled absorption of laser light in the target tissue is extremely important. In such procedures, large areas of the human body should be uniformly and quickly illuminated. An effective procedure must be ensured, to reduce the number of recurrences and processing time. On the other hand, care must be taken not to overheat the tissue, which could result in serious complications.

Function

The developed laser system contains an alexandrite wavelength source, that is optimally absorbed in the target tissue during the procedure. The laser light is directed to the skin surface, with a scanning head covering an area of 84x84 mm and incorporating systems to simultaneously cool the tissue surface and monitor its temperature. This makes it possible to warm the subcutaneous tissue in a controlled manner, while keeping the surface temperature constant.

Innovation

The developed system is unique in the global market, providing significantly better control of laser procedures than the existing systems. The laser scanner head has two integrated innovative systems for active skin cooling and temperature control.

Effects

Improved effectiveness of laser dermatological procedures.

Areas of Application

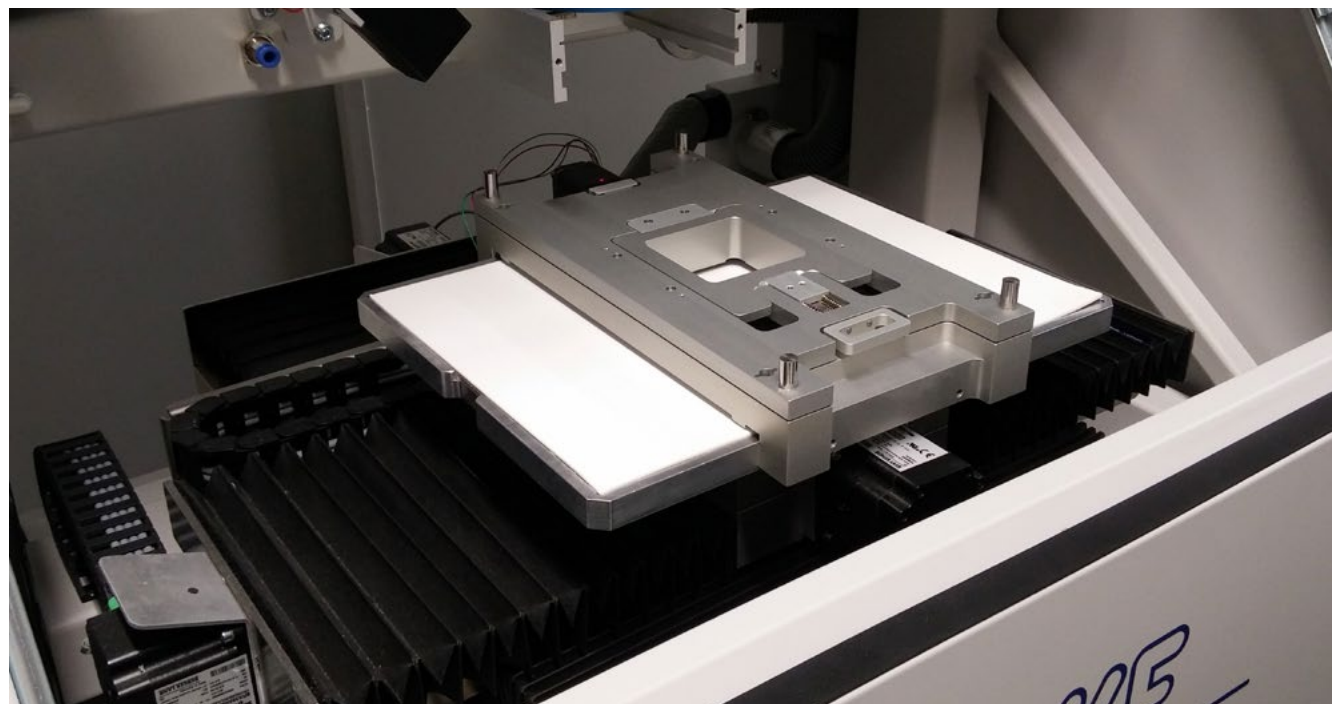Laser medical procedures, dermatology and aesthetic medicine.

Contributing Partners

- Fotona d.o.o. (www.fotona.com)
- University of Ljubljana, Faculty of Mechanical Engineering, Laboratory for Laser Techniques (fs.uni-lj.si)
- Optotek d.o.o. (www.optotek-medical.com)
- LPKF d.o.o. (www.lpkf.com)

More Information

- Nejc Lukač (nejc.lukac@fotona.com)

LASER TRANSFER PRINTING PROTOTYPE

The developed laser transfer printing module enables the printing process of different high viscose donor pastes and inks without using additional tools.

Purpose

In the industry, printing of inks and high viscose pastes is mainly performed by the screen printing process. This process requires stencils with defined end geometry, which are expensive from the purchase and storage point of view. At the same time, it is not possible to make changes to the stencil geometry after it is produced. A random geometry transfer of high viscose donors on different materials was analysed, by using the laser transfer printing process [LTP].

Function

Research has been made in the field of laser transfer printing, where the donor material is transferred from the donor carrier side to the acceptor side using only laser light. In the first part of the research, the analysis of interaction between laser light of different wavelengths (355 nm, 532 nm in 1064 nm) and different donor materials (car window inks, silver, silver-palladium and copper pastes) has been made. The obtained results were used as requirements for the development of a module prototype, which supports the laser transfer printing process on Laser systems from the LPKF ProtoLaser family. In cooperation with the Faculty of Mechanical Engineering, University of Ljubljana, and LPKF SolarQuipment, additional research on LTP process implantation to industrial environments was carried out.

Innovation

The laser transfer printing process is the first process that enables a digital mode of printing high viscose pastes and inks. Using the LTP module, we proved the ability to print various high viscose pastes and inks, where the geometry of the sample is not limited by stencil geometry but can randomly be changed by digital data. The process also enables wet on wet printing, which eliminates the drying phase in the production process and in this way simplifies and shortens the printing process in case of different donor materials on the same sample.

Effects

The laser transfer printing process enables printing of high viscose materials with flexible geometry, without using stencils with a predefined geometry. This way, the rigidity of current processes and costs for stencil purchase and storage can be removed.
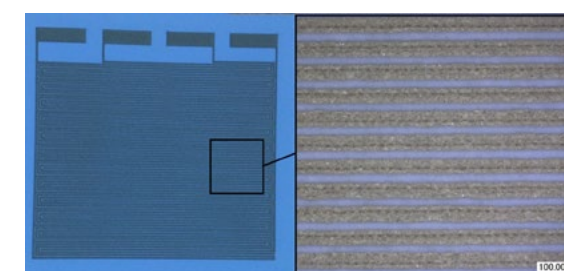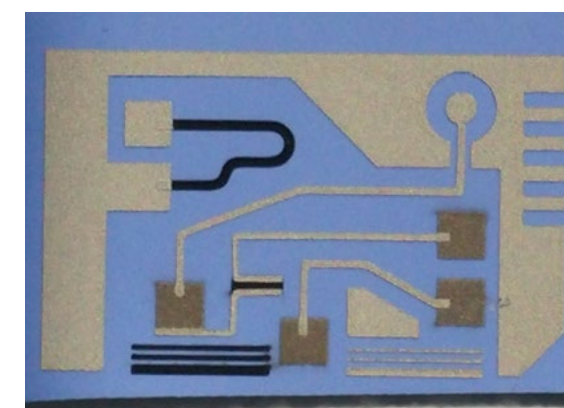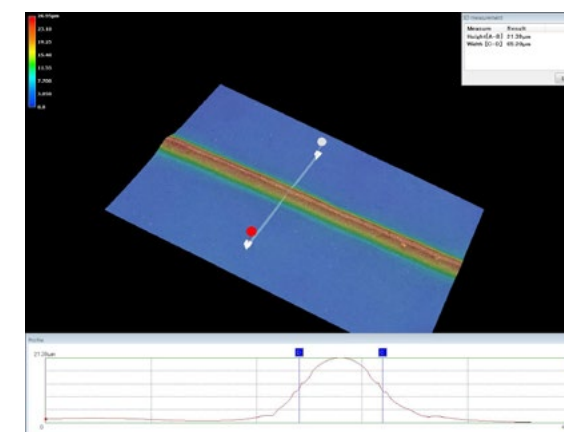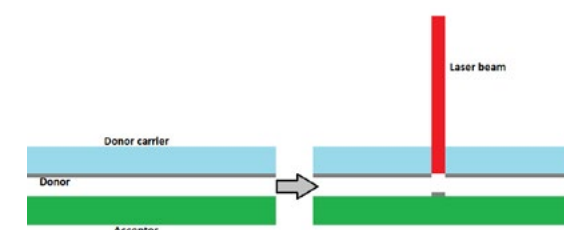
Areas of Application
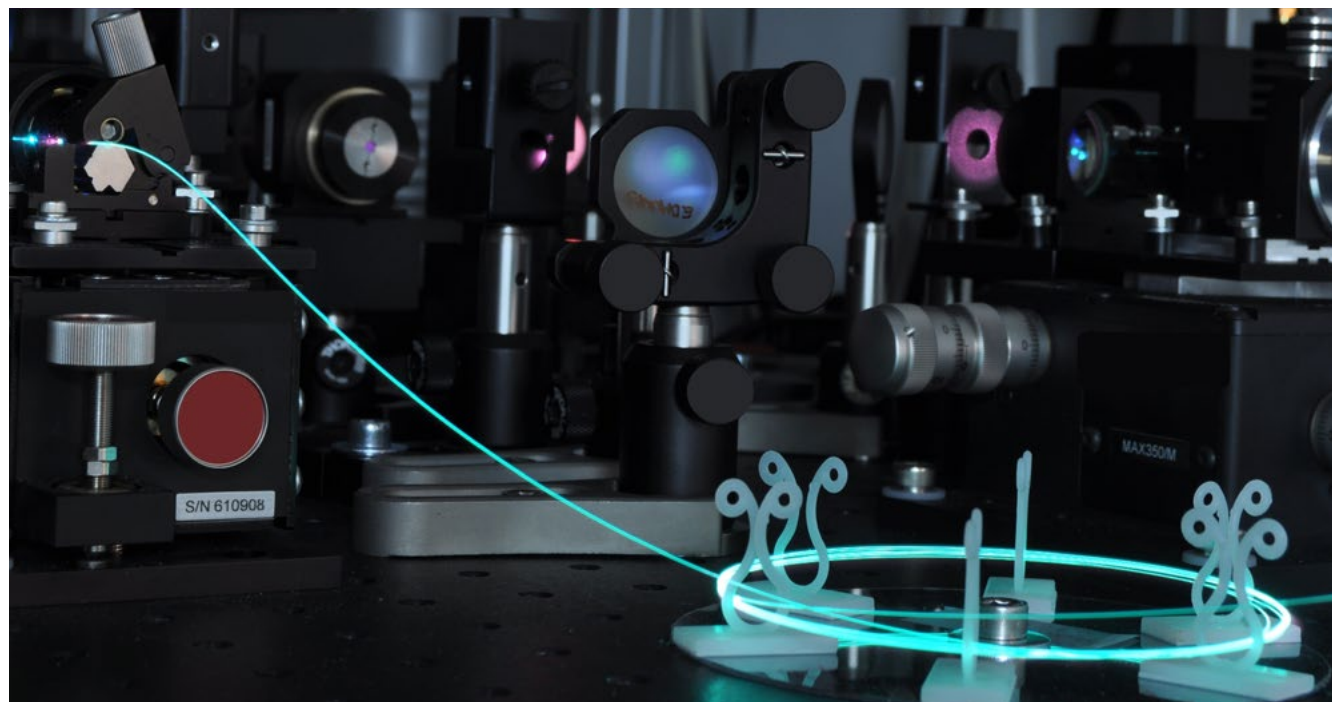
Electro industry, auto industry.

Contributing Partners

- University of Ljubljana, Faculty of Mechanical Engineering (fs.uni-lj.si)
- LPKF SolarQuipment (www.lpkf.com)

More Information

- Jernej Marzel (jernej.marzel@lpkf.com)

PROTOTYPE OF A QUASI CW (QCW) LASER FOR HIGH-SPEED LASER TRANSFER PRINTING

For fast and precise laser transfer printing, a high-power laser source is needed, which enables arbitrary modulation of the laser light in a wide frequency range. The developed prototype allows for much faster operation in comparison to the existing systems.

Purpose

The purpose of the project was the development of a quasi CW (QCW) laser for high-speed laser transfer printing. The industry today needs highly adaptable laser tools for fast and precise processing. For the application of laser transfer printing, which is done on large surfaces at high precision, a high-power laser source, allowing arbitrary pulse generation in a wide dynamic range, is needed.

Function

The quasi CW laser uses an additional (idler) seed source, which is combined with the primary seed source and amplified in several fiber amplifiers. Fast switching between the two sources and efficient filtering of the primary laser light at the output of the amplifiers enables fast output power modulation, while suppressing the transient effects.

Innovation

The main shortcoming of the existing laser systems is that they demand a compromise between the output power and the modulation frequency and thus do not allow for further advancement in printing speed. The developed laser prototype is based on the optical fiber technology and is consequently compact and energy efficient. The high modulation frequency is realised by the introduction of the two seed sources, which enable it to gain stabilisation along the am-

plifying chain and, in consequence, the stability of the whole system. The concept allows for further power scalability, as well as an increase of the modulation bandwidth and thus an increase of printing speed.

Effects

The developed laser system, in comparison with established solutions, enables laser transfer printing at higher speeds.

Areas of Application

The developed system can be used in several fields of laser transfer printing (e.g. pigment-based and conductive inks onto automotive glass).
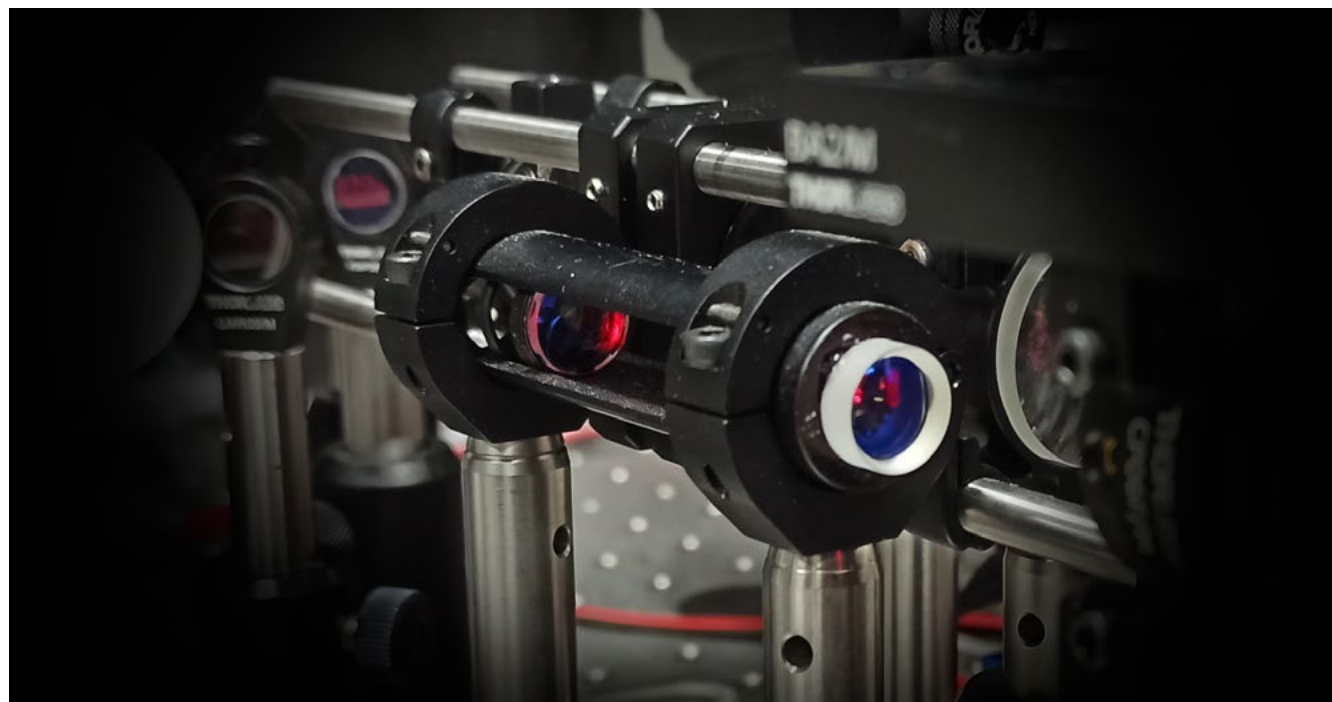
Contributing Partners

- University of Ljubljana, Faculty of Mechanical Engineering, Laboratory for Photonics and Laser Systems FOLAS (fs.uni-lj.si)
- LPKF Laser & Electronics d.o.o (www.lpkf.com)

More Information

- Rok Petkovšek (rok.petkovsek@fs.uni-lj.si)
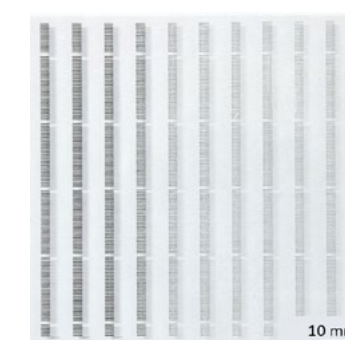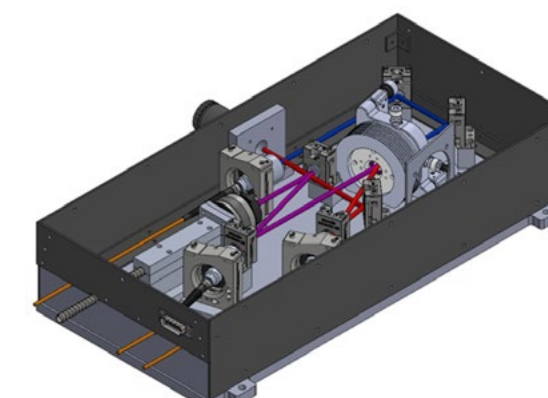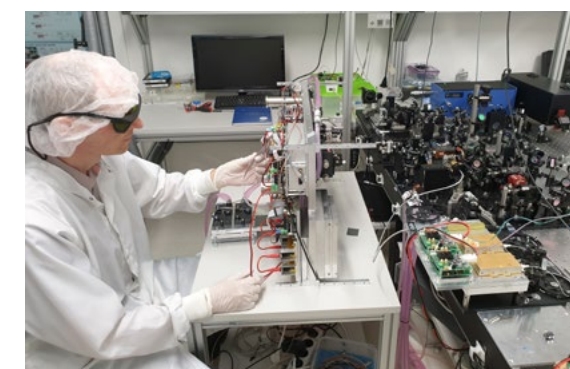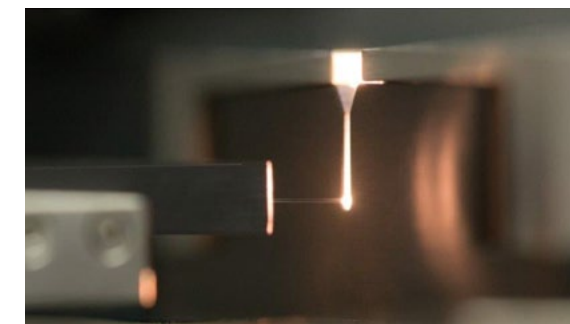
A SMART YAG SYSTEM

The upgrade of the traditional system for YAG capsulotomy enables a safer lens capsule surgery, by controlling the focus position of the laser beam.

Purpose

YAG capsulotomy systems are designed for laser removal of darkened portions of the lens capsule, which is a common complication after cataract surgery. In doing so, traditional systems do not allow effective control of the focus position, which can result in damage to the inserted artificial lenses. The upgraded system eliminates this deficiency with an innovative focus control system.

Function

A new optical system has been researched and developed, which enables the control of the focus position, relative to the lens capsule. With a fast and highly sensitive detection system the upgrade offers improved safety of the surgical operation on two levels - in the mode of restricting the laser beam focus in respect to a predefined distance to the preset plane (e.g. too close to the lens) or in the autofocus mode in respect to the preset plane. The operator still controls the firing of the laser independently, while the system keeps control on the focus position.

Innovation

The newly developed optical system features high positional resolution of up to 20 micrometers and fast millisecond responsiveness. The optical system requires minimal changes to the existing YAG systems, and even those are not related to the main therapeutic part or to the delivered dose of light to the eye and thus do not require additional complicated clinical testing. The additionally upgraded system also allows advanced filtering of various reflections, that otherwise interfere with the operator's control during surgery.

Effects

While testing, ophthalmologists highlighted both of the aforementioned functionalities of the new YAG system upgrade, namely focus control that can prevent lens damage in sudden patient movements, as well as automatic continuous laser focusing, that could greatly increase treatment efficiency. At the same time, they valued the ability of the system to analyse the actuation process itself, in respect to the focus positions as well, because it calls for further improvement of the software support for such a hardware solution in the future.
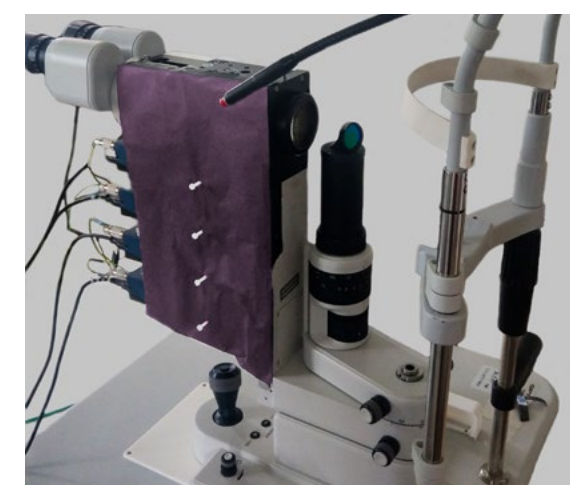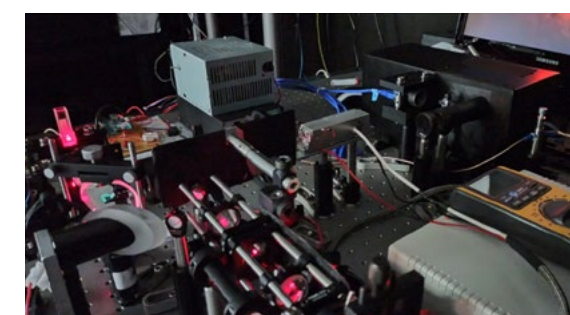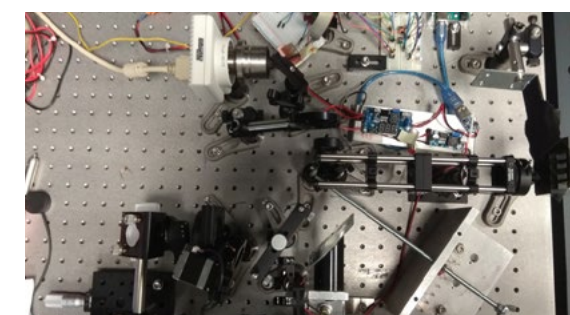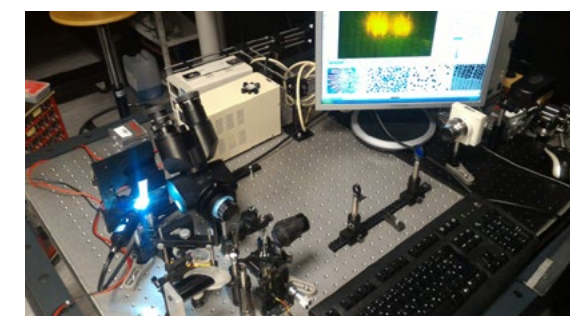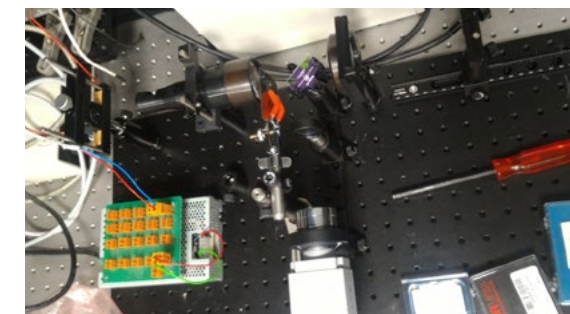
Areas of Application

The laser system is used as an upgrade in ophthalmic systems for YAG capsulotomy.

Contributing Partners

- Jožef Stefan Institute (www.ijs.si)
- Optotek d.o.o. (www.optotek-medical.com)
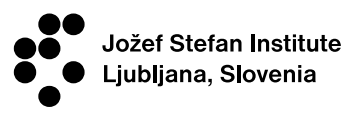- University of Ljubljana, Faculty of Mechanical Engineering (fs.uni-lj.si)

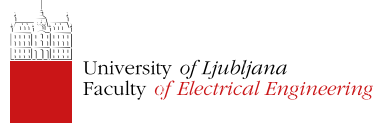## More Information

- Rok Podlipec (rok.podlipec@ijs.si)

PHOTONICS

PARTNERS

RESEARCH & DEVELOPMENT PARTNERS

**Jožef Stefan Institute
Ljubljana, Slovenia**

www.ijs.si

University *of Ljubljana*
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