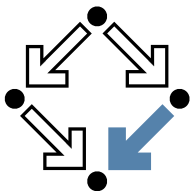


COMPANY REPORT 7.0



RISC

Software GmbH

www.risc-software.at



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Greeting from the Rector **Univ.-Prof. Dr. Meinhard Lukas**

Medical Cognitive Computing Center

Today, central problems in science, business, industry and medicine can only be solved by bundling all available methods, such as those from computer science, mathematics or artificial intelligence. The implementation of applied research projects and the transfer of technology from the university environment to industry are crucial for the development and competitiveness not only of the universities, but also of Upper Austria as a business location.

Without its institutes, scientists and spin-off companies, Johannes Kepler University would not have been a leading driver of innovation for more than 50 years. One of these drivers of progress is RISC Software GmbH - it and the associated Institute for Symbolic Computing have developed into a global brand. RISC Software GmbH has been highly successful in research and development for over a quarter of a century. This involves applied research, experimental development and technology transfer through to basic research in the field of professional software development.

RISC Software GmbH emerged from the RISC Institute of the JKU Linz and is therefore still deeply connected to the university environment.

The future of medicine lies in artificial intelligence

The use of artificial intelligence in medicine not only gives us the chance to diagnose diseases earlier or to monitor disease progression more effectively, but also to treat people more efficiently and successfully. Today, this requires a synthesis of medical expertise and machine data processing methods.

The keyword for Linz is MC3. The Medical Cognitive Computing Center combines the knowledge of the three know-how providers JKU, Kepler University Hospital and RISC Software GmbH. Several research groups at JKU are already working very successfully in the field of artificial intelligence. All at the Institute for Machine Learning, which is

headed by Prof. Dr. Sepp Hochreiter. Here, scientific expertise in machine learning is applied to biology, genetics and medicine.

As part of the MC3 project, a center will be created that will combine the fields of medical research and AI research into a combined focus for the healthcare system in Upper Austria.

For more than ten years, all clinical data has been collected in a warehouse. This allows them to be exported anonymously for prognosis models and used in accordance with legal regulations. In addition, the close collaboration between physicians, bioinformaticians or medical informaticians and AI experts enables a deeper understanding of the issues to be addressed.



Univ.-Prof. Dr. Meinhard Lukas
Rector Johannes Kepler University Linz



Greeting by the Chairperson of the Supervisory Board **Mag.ª Christiane Tusek**

As a spin-off of the RISC Institute of the Johannes Kepler University Linz, RISC Software GmbH operates between the poles of tension between a non-profit organization and a profit-oriented company. On the one hand, the mission is to transfer the results of basic research to the economy in a beneficial way; on the other hand, a company can only survive in the long term in a competitive environment if there is economic stability.

RISC Software GmbH, which is majority-owned by Johannes Kepler University Linz, has been a flagship in the investment portfolio for years.

Johannes Kepler University Linz sees itself as an internationally oriented university with strong regional roots, and attaches great importance to its roots in society and the economy. In order to further expand its areas of competence, it relies on innovative strength through interdiscipli-

narity. This is precisely where RISC Software GmbH is a pioneer with its interweaving of mathematics and computer science. With an equity ratio of well over 50 %, the company is on solid financial footing. The growth of the last few years is reflected in the increasing number of projects as well as the operating performance.

The workshop series "RISC AI ACADEMY" organized by RISC Software with numerous participants from industry and business shows, on the one hand, the bundled competence of RISC Software GmbH in the field of artificial intelligence and on the other hand the connection to companies from Upper Austria.

Thanks to all employees of RISC Software GmbH on behalf of the Johannes Kepler University Linz for their commitment and continued success!

Mag.ª Christiane Tusek
Vice Rector for Finances
Johannes Kepler University Linz



Greeting by the Member of the Supervisory Board **Mag.ª Ingrid Rabmer**

The issues of health and an aging society are among the major challenges of our time. With its comprehensive know-how from production research, the UAR Innovation Network also makes a significant contribution to overcoming a wide range of challenges in medical technology. RISC Software GmbH, an associated company of UAR, is a key player within the group.

In addition to its innovation expertise in the areas of IT, logistics and industry, the research company can point to many groundbreaking developments in the field of medical technology, which is a rapidly growing field of the future. Applications developed by RISC Software GmbH support medical professionals in planning and training highly complex operations, among other things.

With this expertise, the research company is also heading the MEDUSA (Medical EDUcation in Surgical Aneurysm clipping) lead project. The lead project is part of the "MED UP - Medical Upper Austria" initiative of the state of Upper

Austria and was launched as part of the strategic economic and research program "Innovative Upper Austria 2020." In highly complex operations on the brain, every tiny movement is crucial. A total of 13 research partners are working in close coordination to develop a simulation system with which neurosurgeons can plan highly complex brain operations in detail and train them extensively in advance. This will ensure maximum certainty of success for the patients concerned.

RISC Software GmbH understands how to translate research results into forward-looking innovations and thus holds its own in the innovation environment in the long term. I would like to take this opportunity to congratulate the entire team at RISC Software GmbH on many outstanding successes and to express my sincere thanks for their commitment.

We look forward to further good cooperation and wish continued success.

Mag.ª Ingrid Rabmer
Investment Management / CFO
Upper Austrian Research GmbH



Greeting by the Member of the Supervisory Board Univ.-Prof. Dr. Peter Paule

Multiplication tables and modular functions

The now famous BBC Nova production “The Proof” (1997) by John Lynch and Simon Singh documents the story of Fermat’s conjecture and its proof by Andrew Wiles after more than 350 years. In the video interview Wiles states:

“There’s a saying attributed to Eichler that there are five fundamental operations of arithmetic: addition, subtraction, multiplication, division, and modular forms”; see the video transcript at <https://www.pbs.org/wgbh/nova/transcripts/2414proof.html>.

Loosely translated, the quote means that in addition to the four basic arithmetic operations, there is a class of mathematical objects of fundamental importance: modular forms.

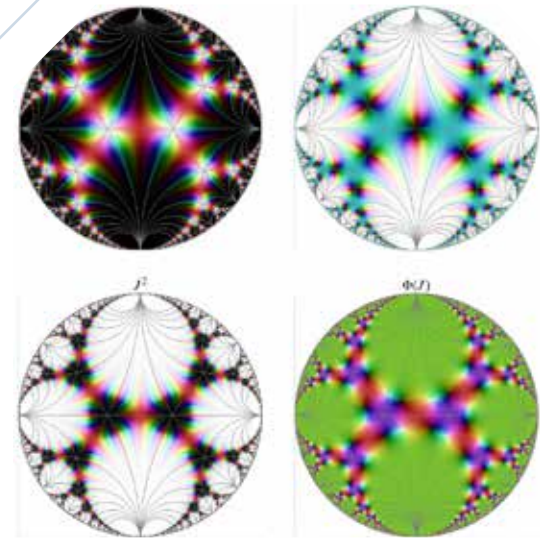
Modular functions are not only essential for the proof of the Fermat conjecture, but have countless applications in mathematical fields (number theory, analysis, etc.) but also in physics. Here the applications range from the gravitational theory of black holes (e.g., in a theory by Edward Witten, who is the only physicist so far to have received the

Fields Medal, the most important mathematics prize) to quantum field theory: Two books on this subject have been published by Carsten Schneider (RISC) and his project partner Johannes Blümlein (Deutsches Elektronen-Synchrotron DESY, Berlin-Zeuthen) in the Springer RISC series “Texts and Monographs in Symbolic Computation.” The RISC Software GmbH was and is an industrial partner in the framework of EU-funded Blümlein-Schneider projects.

What are modular functions? Briefly and informally, generalizations of periodic functions such as sine and cosine. If you extend such functions from real to complex numbers, you can visualize the sine, for example, as in Figure 1. Modular functions have symmetry properties of a more general and complicated nature. Thomas Ponweiser, a former employee of RISC Software GmbH, has created programs to visualize such symmetries; see Figure 2. Currently, computer algebra algorithms are being developed in my RISC work group to support research and work with modular functions.

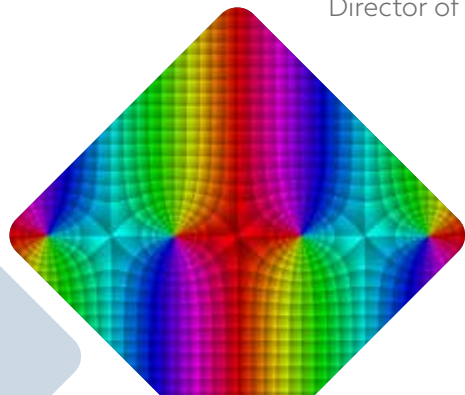
An example: The number of partitions of a number is defined as the number of additive decompositions of this number. Example: 4 has five such decompositions: 4, 3+1, 2+2, 2+1+1, 1+1+1+1; in short: $p(4)=5$. The famous Indian mathematician Ramanujan (1887-1920) noticed that the partition numbers $p(9)=30$, $p(14)=135$, $p(19)=490$, $p(24)=1575$, etc., have a common property: The final digit is either 0 or 5.

Ramanujan then conjectured, and later proved, that this holds for all partition numbers $p(5n+4)$, $n=0,1,2$ and so on. In recent years, Cristian-Silviu Radu (RISC) has developed an algorithmic method by which such statements can not only be automatically proved, but even discovered. This method, recently implemented by Nicolas Smoot (RISC) in a PhD project, is entirely based on new theory for classical modular functions!



Picture 1: *E. Wegert, Visual Complex Functions, Birkhäuser, 2012.*

Univ.-Prof. Dr. Peter Paule
Director of the Institute for Symbolic Computing (RISC)
Johannes Kepler University Linz



Picture 2: Th. Ponweiser, Computer Algebra and Analysis: Complex Variables Visualized, Master Thesis, 2014.



Preface of the Managing Director **DI Wolfgang Freiseisen**

It is probably common knowledge that RISC not only stands for a special processor technology ("Reduced Instruction Set Computer"), but is also the abbreviation for "Research Institute for Symbolic Computation,"

However, it is less known that the founder of the RISC Institute, Prof. Bruno Buchberger, had considered naming it "Research Institute for Artificial Intelligence" instead of "Research Institute for Symbolic Computation" when he founded the institute about 35 years ago. But since at that time, the topic of artificial intelligence (AI) still seemed a bit too "esoteric" and the field of research too restrictive, he decided on the term "Symbolic Computation," which was clearer from the point of view of mathematics. The fact that this naming was very far-sighted can be seen today, in the "new heyday of AI," the university institutes specializing in this field mostly call themselves institutes for machine learning.

Symbolic Computation - or simply "Symbolic Computing" - is a branch of (computer) mathematics. In addition to classical numerical mathematics, it deals with methods based

on symbols. Such symbols are, for example, abstract structures of simple variables, high-dimensional graphs or complex neural networks.

What is the mission of RISC Software GmbH?

The credo of the RISC Institute has always been to have research, teaching and also the application in one place. These cornerstones of a triangle of forces condition and cross-fertilize each other, thus creating a positive dynamic in research and development, which is also important for the development of RISC's partner companies and is even necessary nowadays. At the beginning, in addition to the basic research groups at the RISC Institute, an industrial group was established to solve the problems of the economy with the methods of mathematics and computer science. However, it soon became clear that this approach was good but risky and not very sustainable. Therefore, Prof. Bruno Buchberger founded a professional R&D company as a spin-off from the RISC industrial group. First called Gödel School GmbH, as a tribute to the great Austrian logician Kurt Gödel. Later, this GmbH was renamed RISC Software GmbH, as the implementation of R&D projects and the



development of innovative software systems emerged as the main tasks. That was more than 30 years ago and since then our mission and our fields of activity have changed only insignificantly.

What is RISC Software GmbH researching?

RISC Software GmbH is a non-university research institution with the research area of applied computer mathematics. Its research is mostly interdisciplinary in the fields of medicine, logistics and industry. The research results are mainly assigned to the research areas Industrial Research and Experimental Development. An overview of current scientific publications can be found at www.risc-software.at/publikationen. A good example from the field of medicine is the Medical Cognitive Computing Center (MC3 for short), which we are establishing together with the JKU (Institute for Machine Learning, Prof. Sepp Hochreiter) under the direction of the Kepler University Clinic (KUK) (Prim. Prof. Jens Meier). The aim here is to apply the methods of artificial intelligence to problems in medicine. Use cases are, for example, the evaluation of the quality of blood reserves or the prediction of possible heart complications in intensive care medicine in order to initiate appropriate measures.

Does RISC Software GmbH conduct "AI research"?


"AI research" in the sense that new methods of AI are sought and developed - definitely no! This basic research is the task

of the universities. "AI research" in the sense that existing methods of AI are applied to practical problems and further developed - definitely yes.

This means that RISC Software GmbH solves practical problems using the methods of computer mathematics and computer science, and AI methods, especially machine learning, play an essential role in this. The tools for this have always been methods of computer mathematics, optimization, simulation, computer geometry, as well as methods of computer science and statistics. What has actually changed are the methods, the thematic focus (in the past modeling and simulation and now also machine learning), and most importantly the toolboxes of computer science.

RISC Software GmbH's toolbox is not only constantly being developed further, but the individual tools are also constantly being improved. Of course, RISC Software GmbH has also been using Big Data technologies, data analytics and machine learning for years, in addition to the proven methods of mathematics and computer science. But these methods are seen as a means to an end - namely to solve existing problems in practice and to make them repeatable in a structured way by means of software development and thus to automate them. →





→ An exciting example from the field of medical informatics is the lead project Medusa (Medical EDUcation in Surgical Aneurysm clipping), in which RISC Software GmbH is working with twelve other Upper Austrian partners from research, medicine and business to further improve the treatment of aneurysms. Methods of medical image processing and simulation are used here, among other things for medical training.

Why can RISC Software GmbH do medicine as well as industry and logistics?

The beauty of the tools from computer science and mathematics is that they can be used regardless of the application area. Thus, these methods can be applied in both medical and industrial settings. For example, flow analysis tools can be used to analyze blood flow as well as to model the solidification process of liquid steel or to simulate high-voltage flashovers in photovoltaic electronics.

However, RISC Software GmbH is almost always allowed to communicate and also publish about medical problems and solution approaches, whereas industrial topics must mostly be treated confidentially for reasons of competition. In the sense of a professional and responsible cooperation and in order to maintain the competitive advantage of our industrial partners, RISC Software GmbH takes this topic very seriously.

Nevertheless, this company report with some very nice application examples from industry, logistics and medicine should give a good insight into the company as well as into the projects and research services.

I hope you enjoy reading it.

DI Wolfgang Freiseisen
Managing Director RISC Software GmbH



Preface of the Technical Manager **Robert Keber**

Digitalization up to date

The shift from our “analog” society to a “digital” world is in full swing. Moreover, recent events have underscored the need for it. The spread of the coronavirus has presented us all with major challenges. Economically, the volatility of demand, unstable supply chains, and also dynamics in the area of resources, such as changes in the availability of materials or personnel at short notice, have created completely new conditions for production and logistics. But communication has also changed: The use of video conferencing tools has continued to enable internal and external communication, thus preventing a complete standstill and providing additional impetus for digitalization.

Digital transformation is not just the direct conversion from analog to digital processes. Redesigning processes and the business models behind them can have a significant impact on a company’s economic success.

A “digital” mindset is necessary for this transformation to succeed. RISC Software GmbH supports companies on their way to a digital future. Its employees offer modern software development expertise to map processes efficiently

in existing IT systems. Agile methods are used to guarantee flexibility and to develop innovative solutions. But new technologies also play an important role. As an example, I would like to mention the newly created focus on Natural Language Processing (NLP), which supports the automated integration of documents in the digitization of processes.

But also comprehensive domain know-how from the fields of medicine, industry, production and logistics helps to better understand processes and to support them in “rethinking.” In the production environment, we often talk about Industry 4.0, which refers to the networking of machines and sensors (Internet of Things).

The employees of RISC Software GmbH support you in the collection and analysis of this data, using the latest methods from the fields of artificial intelligence (AI), Big Data and data analytics. With this database, optimal just-in-time planning and control of production is possible, incorporating current sensor data from production but also the dynamically available resources.



With Prescriptive Analytics - a newly created focus in RISC Software GmbH - the competencies from the areas of mathematical optimization, simulation, forecasting and artificial intelligence are bundled and expanded to develop state-of-the-art solutions that meet the current requirements of digitalization in the area of production planning and control.

By carrying out research projects, RISC Software GmbH wants to ensure that its competencies are continuously expanded and are always at the cutting edge of technology. In this way, RISC Software GmbH wants to continue to be a competent and reliable partner for your digitization projects in the future.



Robert Keber
Technical Manager RISC Software GmbH



The RISC Software GmbH units

Three business areas and one area of expertise of RISC Software GmbH

Based on an extraordinary combination of competencies in mathematics, computer science and practical experience in both industrial processes and engineering, the interdisciplinary teams of RISC Software GmbH develop (individual) software solutions for business and industry. The special feature of RISC Software GmbH is the combination of scientific know-how in mathematics and computer science as well as the ability, acquired over the years, to transform complex and demanding problems into useful and sustainable software.

Customers receive solutions that they actually need for their work processes and that give them decisive competitive advantages over their competitors. Consequently, RISC Software GmbH is divided into four areas. The three application-oriented areas research and develop solutions for engineering, industry, logistics, information technologies and medicine. In the fourth area, the interdisciplinary competence area Domain-specific Applications, individual professional software solutions are implemented for special areas with agile development processes.

Industrial Software Applications Unit

The Industrial Software Applications Unit (RISC-ISA) unit conducts application-oriented research for industrial manufacturing and production. It specializes in simulations, analyses and optimizations in technical disciplines. The software developed meets the high quality requirements and complex challenges of high-tech industries such as mechanical engineering, automotive or aerospace.

Logistics Informatics Unit

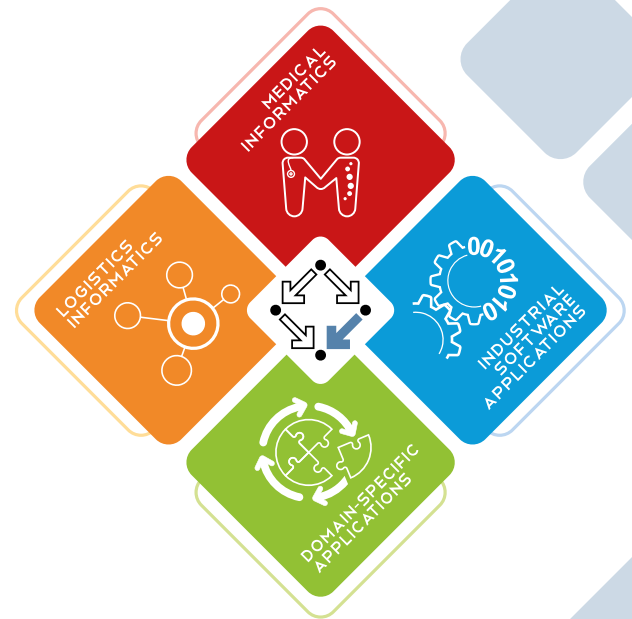
The Logistics Informatics Unit (RISC-LI) conducts application-oriented research for logistics and industrial processes as well as applied mobility research. It designs and develops software for the planning, optimization, simulation and control of processes and forms the bundled expertise in the areas of smart transport logistics, information systems for logistics networks, and material flow and production planning. Digitization efforts offer unprecedented opportunities in the production and logistics environment. Statistical processes, modern methods from the field of data and visual analytics as well as machine learning are applied. Industry knowledge is just as important as technical know-how and application-oriented research in these areas.

Medical Informatics Research Unit

The Medical Informatics Research Unit (RISC-MI) conducts application-oriented research for modern medicine. Research focuses on medical image processing, patient virtualization, biomechanical modeling, medical simulation, medical data analysis and new diagnostic methods. In close cooperation with medical partners, scientifically-based software used internationally in medicine is developed.

Domain-Specific Applications Unit

The Domain Specific Applications Unit (RISC-DSA) unit is the area of expertise where everything revolves around data management, agile software development and the development of innovative and individual (web-based) software systems. By using the latest web-based software technologies in combination with Big Data technologies and with agile software development, domain experts from a wide range of specialist areas obtain stable, adaptive and expandable software systems for their company and/or production processes. The RISC-DSA competence area has a cross-sectional function within RISC Software GmbH and thus supports all three business areas. The employees of RISC Software GmbH work in agile teams on customized solutions for their customers. From the initial idea to roll-out, RISC-DSA supports all phases of the process lifecycle, while the projects are continuously supervised by certified coaches in order to continuously improve the software development cycle.



Pooling of strengths and cross-divisional cooperation

These, at first glance, completely different areas are linked by the symbiotic combination of mathematics and software engineering together with industry know-how to create software solutions for business. The aim is not to separate but to bundle the various strengths in the specific disciplines. The exchange among each other is an important principle and part of the corporate culture. Accordingly, many projects are handled on a cross-divisional basis.

DI Wolfgang Freiseisen
Managing Director RISC Software GmbH



Stable corporate development with continuous growth

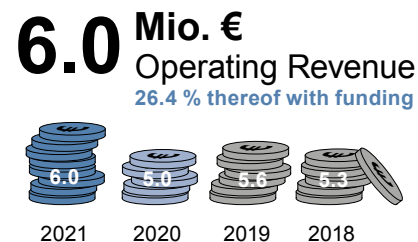
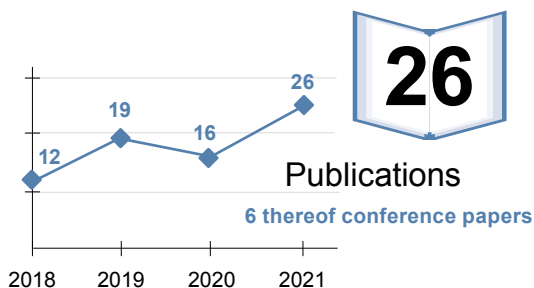
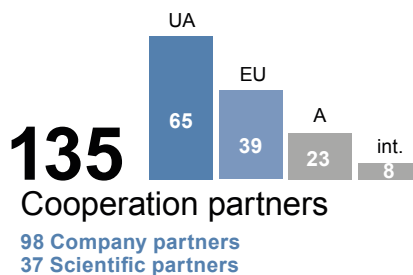
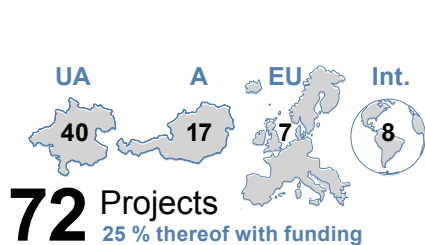
There are certainly different views on the subject of key figures or, in new German, key performance indicators (KPI). As a prospering and agile research company, RISC Software GmbH does not have the very highest demands in this regard, but due to many years of continuous growth, certain key figures have become indispensable for managing the company. In addition, the key figures offer the opportunity to present RISC Software GmbH from a different perspective and thus make a solid contribution to an overall picture that is clear and as complete as possible.

Since the performance of the employees is crucial for success, their number is a very important indicator. Of the 75 employees in 2021, 33 % were women and 83.5 % worked in research and development. The operating performance includes all economic revenues within a fiscal year and currently amounts to approx. 6 million euros with an equity ratio of approx. 58 %. This is implemented in 72 projects with approx. 135 cooperation partners, of which 98 are company partners and 37 are scientific partners. Of these 72 projects,

approx. 55 % are carried out regionally in Upper Austria, approx. 24 % in Austria and approx. 10 % EU-wide. From the point of view of RISC Software GmbH, the number of projects is purely a measure and naturally does not contain any statements about size, quality, complexity and sustainability. The result is clearly positive and a part (approx. 20-50 %) is again reinvested in research and development.

The research ratio has stably ranged between 30 % and 35 % for many years. It describes all revenues from funded projects (national and from the EU) and is currently around 34 %. This figure does not include company-funded projects (excluding government research grants). Publication performance is not a primary goal at RISC Software GmbH, but is becoming increasingly important. As a research institution, RISC Software GmbH also strives to make valuable contributions in this area. In 2021, there were 26 publications. For 2022, 30 publications are planned. The majority of these have been and will be published by colleagues from the Medical Informatics Unit.

Key Figures 2021



Mag.^a Dr.ⁱⁿ Andrea Kurz
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CONTACT



RISC Agile Academy

Coaching and training in the introduction and consolidation of agile methods

For more than two decades, agility has been touted as the miracle cure in project and product management. However, since the introduction of frameworks such as XP, Scrum, Kanban, etc., one still observes failures in projects in the software environment. Experience with agility shows that there is no blueprint that can be used as a solution to any problem. Rather, agile methods require experience and calmness to take the necessary actions at the right moment. Certified coaches from the RISC Agile Academy pass on this experience to their customers.

What is agility, anyway?

Agility is not a project management method. Agility is not a leadership style. Agility is not responsiveness to late changes. Agility, in its pure form, is merely a mindset. An attitude or commitment to that way of doing our work. This way follows proven principles, which can be implemented through myriad practices. The term agile usually comes up in reference to software projects, but this viewpoint is clearly too narrow. Agile methods now target many areas,

from individuals to teams, to departments, to the corporate organization or group structure. Advantages become particularly apparent in the area of merging strategic and operational goals and tasks. Properly practiced, agility leads, among other things, to high-performance teams, high-quality and competitive products, increased customer satisfaction, and - thought of on a larger scale - to robust, fit-for-purpose companies.

The Portfolio

The RISC Agile Academy has set itself the goal of bringing the proven methods in theory and practice to its customers. For this purpose, a consulting portfolio will be officially introduced in 2022, on the basis of which companies with different levels of agility maturity can be helped. Not only one network is preferred, but an attempt is made to combine the correct methods from various networks in a target-oriented way and thus to develop a customized solution. This development takes place in continuous coordination with the customers and partners to ensure that the best possible way is found.



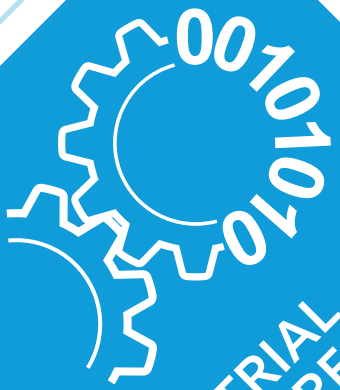
Initial consultation: Determination of wishes, visions or goals. Identification of the next steps.

Package 1	Quick Scan / Quick Help	Uncomplicated, fast and cost-effective - not every problem needs a workshop series to be solved.
Package 2	Training	Workshops with theoretical and practical parts on topics such as Scrum, Kanban, introduction to agile project management, etc.
Package 3	Teamcoaching	Specific support of a customer team in the form of coaching and consulting workshops.
Package 4	Coach the Coach	Sparring partner for a coach at the customer's site. There is no direct contact to the team.

On the part of RISC Software GmbH, a team of certified coaches takes care of the support of the customers. The coaches attend annual training courses in the strategic and operational areas and also apply the knowledge practically to enable knowledge development and transfer at the cutting edge.

DI (FH) Andreas Lettner
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CONTACT

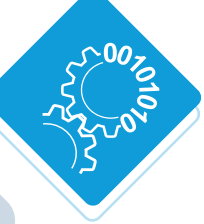


**INDUSTRIAL
SOFTWARE
APPLICATIONS**

Development of software solutions for visualization, simulation and optimization of product development and manufacturing processes in industry.

Software developments for areas of virtual product design and for the simulation of manufacturing processes and control systems are the focus of the work of the Industrial Software Applications (ISA) unit.





Virtual product development

Today, software systems for realistic and detailed simulations are central tools for the development of high-tech products and systems in many areas of industry. In the application area of virtual product development, the ISA unit deals with new developments and further developments of the necessary technical and scientific software systems.

On the one hand, the staff members work on further possibilities of combining multidisciplinary, distributed analysis systems, so that virtual products can be modeled as comprehensively as possible with all their properties and requirements. Due to the constantly increasing number of design possibilities (for example, new materials or more flexible manufacturing methods), mathematical optimization methods are becoming more and more important in this context.

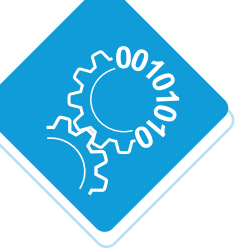
On the other hand, the department deals with the development of design and construction tools for integrated, decentralized product development processes.

Manufacturing processes and control systems

In many branches of the manufacturing industry, production processes and control systems are decisive factors for quality, competitiveness and cost efficiency. Precise and meaningful simulations as well as reliable statements on new manufacturing processes enable existing potentials to be used in the best possible way. The results of our work include a software library for the simulation of machining processes as well as programming and simulation environments for computer-controlled machine tools.

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CONTACT



Application Engineering Tool

Digitization puts customer requirements at the center

Digitization is changing the world we know

Digitization is permeating more and more areas of life and business. For industry, it offers the opportunity to better tailor products to individual customer requirements and to produce more efficiently. Digitization should therefore be seen not only as a challenge, but above all as an opportunity.

For Miba, as a strategic partner to the international engine and automotive industry and a technology leader in the area of friction systems, digitization is a key issue. Together with RISC Software GmbH, a tool for the system-supported development of friction systems was realized, thereby significantly improving not only the efficiency but also the standardization and transparency of the design process.

The know-how secured in the form of software is now available to all employees worldwide and provides them with the freedom to concentrate on the really demanding and value-adding activities and consequently to bring new products to market more quickly.

Long-term cooperation as a success factor

RISC Software GmbH has been supporting Miba in the agile implementation of the project since the beginning of 2014. In the course of a preliminary project, the concept, which had already been worked out in detail by Miba in advance, was jointly refined and an initial prototype was realized. At the beginning of 2015, the actual implementation began and, thanks to the close and intensive cooperation, the first expansion stage of the software was successfully rolled out within the Miba Group at the beginning of 2016. Since then, the software has been successfully used in all subsidiaries of the Miba friction materials group of companies worldwide.

Using the Application Engineering Tool, Miba application engineers can now define, analyze and evaluate the requirements and design of the planned tribological system (brakes and clutches) together with customers. The analysis and evaluation is based on a powerful and flexible calculation kernel, which is used to determine the characteristic system parameters and process them for the user in the form of

meaningful visualizations (diagrams, plots, etc.). In the meantime, the support of the user goes so far that concrete pavement technologies and pavements are suggested taking into account the parameters entered.

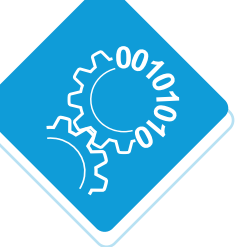
The focus in recent years has been on the development of a cost module. In addition to the technical aspects, the software system thus also supports the cost-technical evaluation of the planned design and shows savings and optimization potentials.

Customer requirements and production costs can thus be matched as closely as possible. The prerequisite for this is the detailed modeling of the production facilities and production processes in order to be able to determine and evaluate production variants for the planned design. Therefore, before realizing the actual cost module, the first step was to implement a tool for modeling production. The core of this tool is a "domain-specific language" (DSL), with which production processes, production rules and the behavior or restrictions of production facilities can be described very precisely and true to reality. The cost module has meanwhile proven itself in the productive environment and is continuously being further developed and extended.



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Geometry modeling in concept design

Parameterized geometry modeling as a basis for multidisciplinary optimization in aircraft design

Today, the design of new aircraft models is more than ever a cost- and time-intensive process due to the high requirements. Starting from a mission profile (payload, range, fuel consumption, etc.), the design process passes through the conceptual, preliminary and detailed design phases. In each of these phases, the requirements of different disciplines, such as aerodynamics, structural mechanics, flight physics or manufacturing, must be optimized with respect to their interactions so that the new aircraft model meets all requirements.

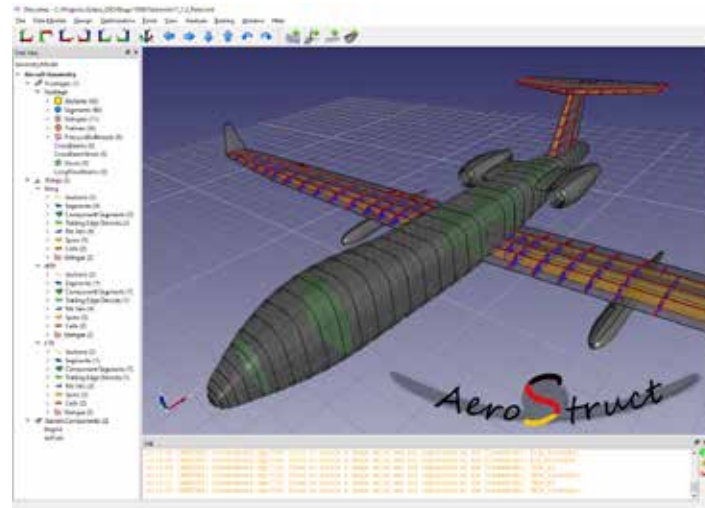
Until a few years ago, the calculations of the individual disciplines were performed independently of each other, so that, for example, the effects of the calculation results of an aerodynamics calculation had to be manually entered into its input model for a subsequent structural mechanics calculation. Likewise, changes to the aircraft geometry had to be manually transferred to the respective models of the individual disciplines.

By integrating multiple disciplines into one optimization tool, which automatically transfers the effects of the calculation results of one discipline into the input model of another discipline, the development process can be accelerated and an optimized result can be achieved in less time. All discipline-specific input models are based on the aircraft geometry, which means that it forms the basis for coupling the calculations from the different disciplines.

To implement this project, Airbus Defence and Space participated in the joint project AeroStruct, which is coordinated by the German Aerospace Center (DLR). In this context, RISC Software GmbH was commissioned to design a software system that combines the existing analysis programs of Airbus Defence and Space in order to achieve synchronous progress of the individual disciplines.

The following work was performed as part of this project:

- Selection of an existing standardized description language for aircraft geometries
- Definition of a parametric geometry model for aircraft based on the description language
- Development of a tool for geometry generation from the description language
- Geometry generation for internal wing structures (ribs and spars)
- Intersection of the wing geometry with the geometry of the internal structures
- Development of a GUI application to manipulate the parametric geometry model
- Development and integration of a data format of the aircraft geometry model including discipline-specific data based on HDF5
- Definition of design variables and mapping to parameters of the geometry model





ARCADES training network

Algebraic representations in computer-aided design for complex shapes

ARCADES (Algebraic Representations in Computer-Aided Design for complex Shapes) is a training network funded under the Marie Skłodowska-Curie program. The goal is to use state-of-the-art mathematical approaches to lay the foundation for a new generation of CAD programs.

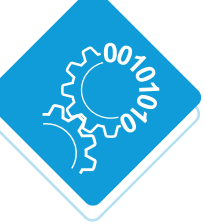
Computer geometry is an important tool in many different application areas of industry. However, the programs in use today are based on approaches to processing data that were developed many years ago. The challenge for ARCADES is to bring together research results from the fields

of algebraic geometry, differential geometry, scientific computing and algorithm design as the basis for novel approaches to solving problems in computational geometry. RISC Software GmbH supervises PhD students within this research network and thus represents an important interface between research work and industrial application.

This project was funded under the Marie Skłodowska-Curie Grant Agreement No. 675789 from the European Union's Horizon 2020 research and innovation program. Further information: <http://arcades-network.eu/>

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Interreg project InnoHPC

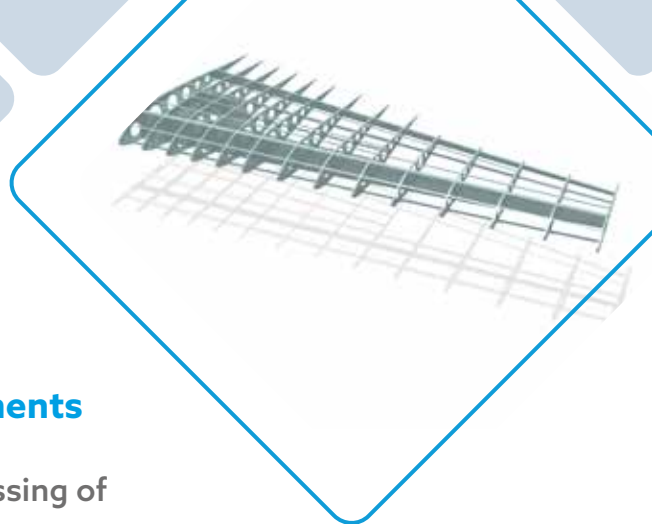
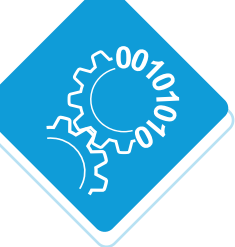
High-Performance Computing for Innovation in the Danube Region

In the InnoHPC project "High-performance Computing for Effective Innovation in the Danube Region," led by the Faculty of Information Studies (FIS) in Slovenia, involved 18 project partners from Europe. The objective was to create a transnational InnoHPC laboratory that bundles regional HPC infrastructures and competencies and a web platform to enable easy access to HPC infrastructure. Furthermore, the sustainability of the InnoHPC Lab beyond the project should be ensured by appropriate measures.

InnoHPC is aimed at SMEs and clusters and offers them the opportunity to increase the efficiency of innovations and to connect transnational value chains in the Danube region. Universities and research institutions in the field of high-

performance computing will gain access to exciting case studies and opportunities to exploit their entrepreneurial potential. Policy makers and business development organizations receive valuable institutional support for their policies and initiatives.

For RISC Software GmbH, InnoHPC offers an opportunity to contribute its competencies in HPC to the project and to further network in the field of HPC in Austria. The InnoHPC project plays a pioneering role in improving the framework conditions for innovation by providing unique institutional and technological infrastructures specifically designed to bring together and exploit HPC infrastructures on a transnational scale.



Static verification of aircraft structural components

Integrated tool for automated control and result processing of verification calculations

More than twenty years ago, Airbus Defence and Space initiated the development of the Strength 2000 application. This is an integrated tool for the static verification of aircraft structural components. The challenge is the lifetime of the software, i.e., Strength 2000 must ensure the availability and traceability of the calculations performed over the lifetime of the structures (military approx. 25-30 years, civil more than 40 years). The aim of the development of Strength 2000 is to automate the performance of the verifications and to relieve users of repetitive tasks.

The application fulfills the following requirements:

- Simplification and automation of the control of the procedures according to the Handbook for Structural Calculations (HSB).
- Parameterization of the calculation procedures with the data from the finite element model, the load data and the CAD data
- Control of the execution of the calculation procedures
- Visualization of the calculation results
- Easy integration of further procedures
- Runability of the program on different platforms (Windows and Linux)

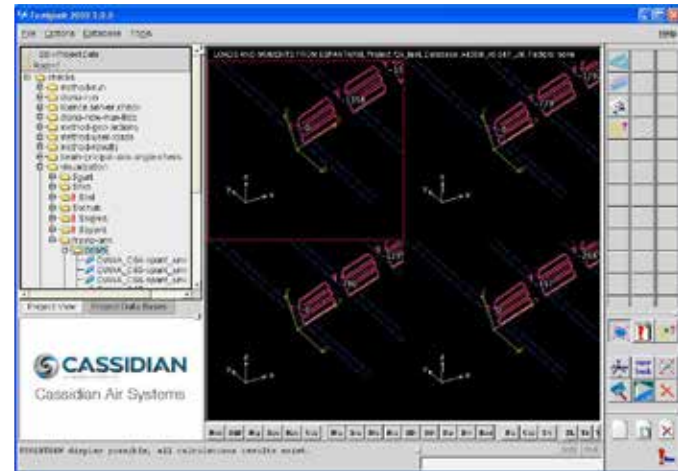
Airbus Defence and Space has approached RISC Software GmbH to analyze Strength 2000 from a software-technical point of view in order to check existing measures or to take new measures that meet the requirements resulting from the long service life of the software. Subsequently, RISC Software GmbH will also be responsible for maintenance and further development.

An important milestone was the restructuring of the finite element analysis post-processor "DIANA," whereby the following work was carried out:

- Ensuring sustainability (maintainability or expandability)
- Restructuring of the internal data model
- Conversion to more efficient storage management
- Support of new structured file formats (HDF5)
- Increase of program robustness
- Reduction of program limits
- Integration into the productive environment

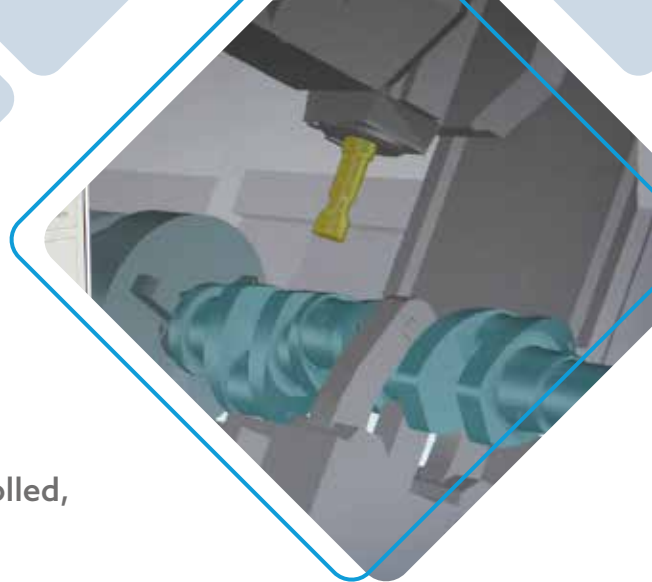
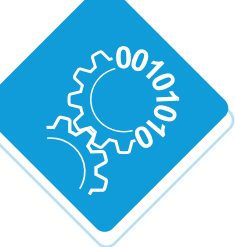
Another milestone was the expansion of Strength 2000 for its external use, with the following activities:

- Improvement of the ergonomics of the user interface
- Analysis of the existing infrastructure regarding user administration and data management
- Development of a help system with associated authoring tool on wiki basis



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NC machining simulation

Simulation and collision avoidance for computer-controlled, multifunctional complete machining centers

The many years of constructive cooperation, characterized by excellence, perseverance and trust, have so far resulted in two software products that have hardly any competition on the international market: CrashGuard Studio and CrashGuard Online Collision Avoidance.

The combination of an extensive, detailed and optimally adapted offline simulation in the CAD/CAM area and a high-performance, memory-optimized and integrated real-time simulation for collision avoidance supports customers of WFL Millturn Technologies GmbH & Co. KG in the use of their complete machining centers. In close cooperation with experts from RISC Software GmbH, software innovation in mechanical engineering fundamentally improves both resource conservation and error prevention in order to increase productivity and competitiveness and thus also underpin market dominance.

CrashGuard Studio

CrashGuard Studio is a 3D simulation software for multifunctional CNC turning, drilling and milling centers, which enables machines with their complex kinematics and ex-

tensive machining and expansion options to be simulated very realistically. An important milestone in the course of the continuous further development of CrashGuard Studio was the material removal simulation, which was implemented on the basis of the Virtual Modeling Library (see p. 38). Analogous to the real machine, the ongoing removal of material can be followed in the 3D visualization in real time. At the end of the machining process, a 3D model of the finished part is available as an additional option for verifying the NC program.

Among the many application areas of the software product are:

- The support in the verification and optimization of NC programs to increase the quality and efficiency of the machining processes and to reduce the risk of rejects and collisions.
- To support the development and design of new machines by providing the ability to test the motion and machining capabilities of a new machine before it is manufactured.

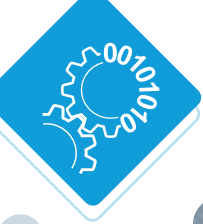
- As a training tool for machine operators and programmers to be able to safely test and understand the diverse possibilities of the machines.

Product development and product maintenance are carried out to a large extent in cooperation with RISC Software GmbH. A large number of problems in the areas of geometry, algorithms and software architecture/software technology were solved by experts from RISC Software GmbH in order to meet the high demands placed on the product. The continuous improvement of the software and future planned extensions underline the successful and trusting cooperation between the two partners.

CrashGuard online collision avoidance

The CrashGuard machine extension for online collision avoidance, another product developed in cooperation between WFL Millturn Technologies GmbH & Co. KG and RISC Software GmbH. →





→ This is a real-time collision avoidance system integrated into the machine control system, the aim of which is to avoid collisions between machine parts of complete machining centers at all times and under all circumstances. To ensure that the simulation model used can always be a little bit ahead of reality, it was necessary to develop new computational methods that are adapted to the special hardware resources of NC machine controllers. The highly optimized core application, including algorithms and data structures, as well as the corresponding preprocessing,

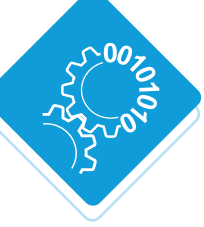
were developed in close cooperation with mathematicians and computer scientists at RISC Software GmbH in order to meet the enormous demands on the correctness and reliability of the system.

The patented system has been successfully on the market since 2005 and is offered as an option for the complete machining centers. Currently, hardly any new machine is delivered without this option, which has increased the number of machines with CrashGuard support to over 200.



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Research project FlashCheck

Arc detection in DC networks: control-oriented identification using compressed sensing and machine learning

Since photovoltaic systems are DC systems, there is a risk of arcing because of poor power connections. These are due to a variety of reasons, such as faulty or aged connectors, human error, and environmental factors. Electrical arcing in a photovoltaic system can lead to a reduction in output energy. In an emergency, arcing can cause a fire that can result in property damage or serious injuries.

Existing arc-fighting safety devices are often optimized for specific applications and result in a high rate of false detection, leading to unnecessary and costly system shutdowns.

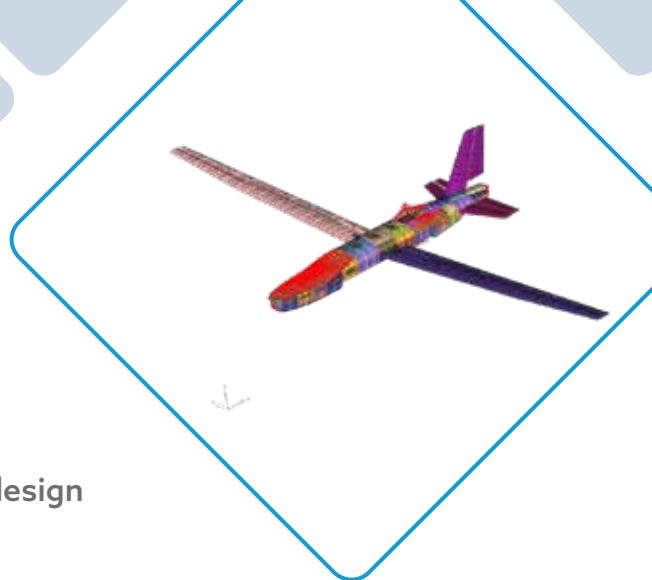
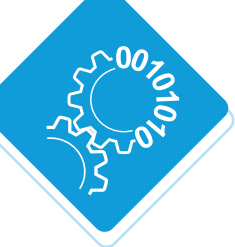
The goal of the FlashCheck project is to develop a general solution for detecting arcing in photovoltaic systems with

the lowest possible error rate. To achieve this, a database of arc signatures is being built using “compressed sensing” methods, which will serve as the basis for detection using “machine learning” technology. RISC Software GmbH is involved in the development and implementation of the compressed sensing methods to reconstruct high-resolution signals at low sampling rates.

FlashCheck is a cooperative research and development project supported by the Austrian Research Promotion Agency (FFG). The project is implemented by Fronius International GmbH with the project partners FH Oberösterreich Forschung und Entwicklung GmbH, RISC Software GmbH and Eaton Industries (Austria) GmbH.

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Multidisciplinary structural optimization


Multidisciplinary optimization system for the detailed design of lightweight composite structures

No other topics have determined the development of aviation from the very beginning like the developments of lightweight structural elements and efficient propulsion systems. Improvements in one of these two areas result in immediate advantages for the performance of an aircraft, for example, in terms of payload, range or fuel consumption.

Together with engineers from Airbus Defence and Space, RISC Software GmbH has been working for more than ten years on the further development of a software system for calculating and designing weight-optimized aircraft structures. Of particular importance here is that the optimum geometry and the best possible use of specialized materials for the overall structure can be considered at the earliest possible design stage. At this stage, the design freedoms are greatest and thus the greatest potential for weight savings is available. To enable this, the Lagrange multidisciplinary structural optimization system has

been developed at Airbus Defence and Space to help optimize lightweight structures with respect to different design parameters. Examples of design parameters include cross-sections of individual components or entire component groups, but also layer thicknesses and trajectories of fiber composite materials.

In addition to the design goal of achieving a minimum weight for a structural element, a large number of different mechanical and physical requirements must be taken into account at the same time. The Lagrange optimization system provides a wide range of relevant multidisciplinary analysis and criteria models. Thus, in addition to a number of mechanical strength criteria and stability criteria, different restrictions regarding natural vibrations, flutter velocities or other aeroelastic interactions can be formulated. A key method for automating the overall design process is coupled aerodynamic-structural analysis (aeroelasticity).

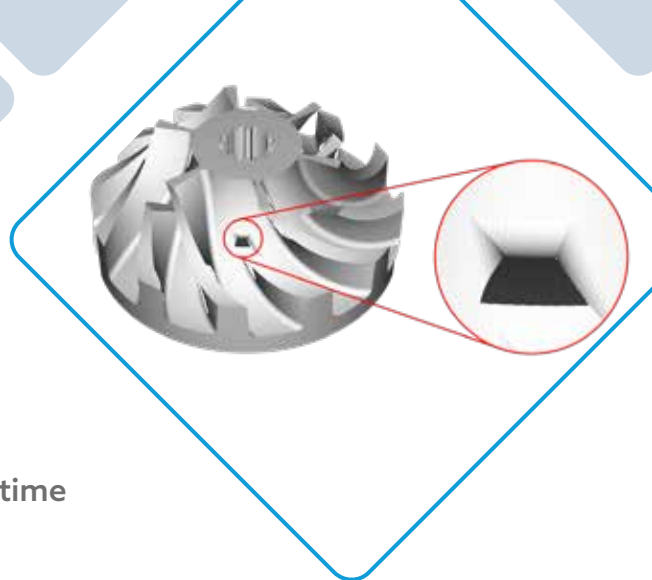
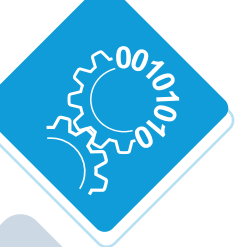


This allows aerodynamic loads to be actively influenced during the design process as part of the optimization in addition to the dimensioning of the structural elements. In addition, Lagrange also allows special manufacturing restrictions for fiber composites to be taken into account, ensuring that the calculated designs can also be manufactured using the available methods. This means that very realistic design drafts, whose models contain several thousand design variables and several hundred thousand boundary conditions, can be optimized right at the beginning of the design phase.

Since 2009, RISC Software GmbH has been the main development partner for the new development of central system parts of Lagrange. Of particular importance is the implementation of state-of-the-art, efficient computational methods and the best possible use of modern hardware platforms, especially with regard to parallel and distributed computer architectures.

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Virtual Modeling Library

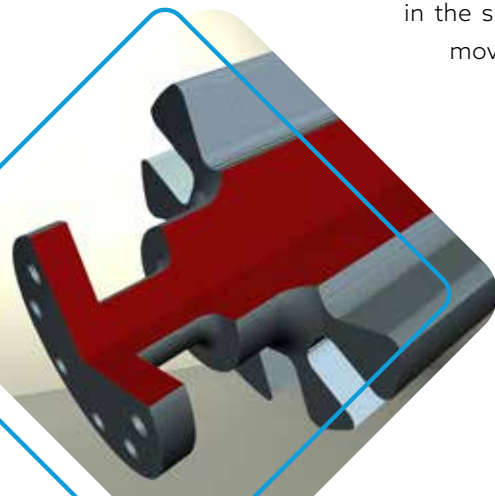
High-precision modeling of detailed geometries in real time

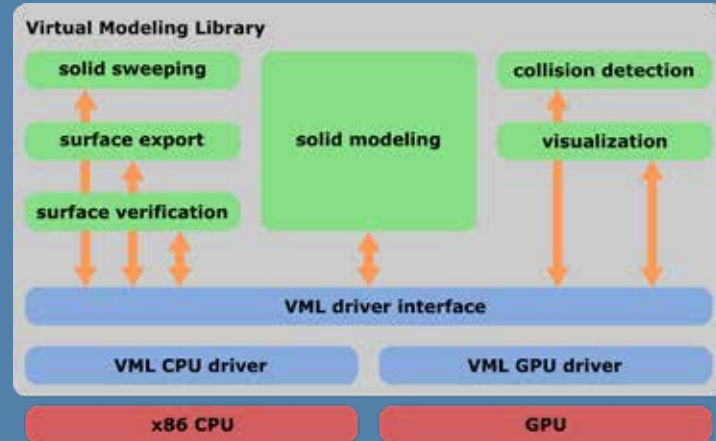
The Virtual Modeling Library (VML) is a software library that implements new algorithms for accurate geometric modeling of solids in real time. It supports operations similar to Constructive Solid Geometry (CSG) and envelope volume calculation. The VML offers good scalability in terms of the number of operations performed during modeling.

Even performing more than 100,000 such operations has little impact on memory and runtime efficiency. This makes the library ideally suited for industrial applications that have combined requirements in terms of geometric accuracy, real-time capability and scalability. This is the case, for example, in the simulation of material removal in machining processes

with a high number of machining steps. In addition to modeling, the VML provides algorithms for interactive visualization, collision detection between any geometry and the current geometry, and surface verification between the current geometry and a reference CAD model. These algorithms also meet the combined requirements.

To ensure real-time capability, the VML implements massive parallel algorithms that exploit the potential of modern hardware architectures such as multi-core central processing units (CPUs) and graphic processing units (GPUs). In addition to the product features already mentioned, the VML offers the export of the surface of the current geometry, the definition of arbitrary section views and the simplicity of integration with other software systems.





Features of VML:

- Solid modeling
- Envelope volume calculation
- High number of operations
- Collision detection
- Surface export
- Interactive visualization
- High accuracy
- Arbitrary section visualization
- Surface verification
- Easy integration

The development of essential parts of the processes implemented by VML was funded by the European Regional Development Fund as well as by the State of Upper Austria within the framework of the Regional Competitiveness Upper Austria Program 2007-2013.

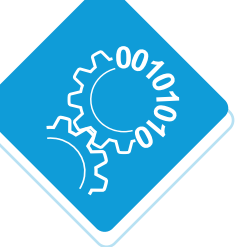
Further information can be found at:

<https://virtual-modeling.at>

Regio 13
Impulse für OÖ
Regionale Wettbewerbsfähigkeit OÖ 2007-2013

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With driverless systems to Industry 4.0

An integrated software system for modeling, simulation and control of driverless transportation systems

Today, driverless transport systems can already be found in numerous production plants, logistics areas or in hospitals for transporting food, medicine and laundry. In the course of current trends (Industry 4.0, Smart Factory), there will be enormous opportunities for driverless transport systems in the coming years, but also completely new challenges.

DS Automotion, a provider of driverless transport systems from Linz that is established in the top international field, commissioned RISC Software GmbH more than 20 years ago with the development of an integrated planning, simulation and control software for driverless transport systems, as well as simulation and control software for freely navigating driverless transport systems. The most important goal for the development of the new modeling and control technology software was a drastic reduction in the imple-



mentation and commissioning times of driverless transport solutions for concrete plants.

Extensively configurable control technology software

The I&C software for controlling the automated guided vehicles was designed as a flexibly configurable standard system with powerful algorithms for dispatching the orders, for collision-free control of the vehicles on the driving course, and for avoiding and resolving deadlock situations. Generic interfaces allow easy adaptation to special requirements of concrete plants and communication with external systems by connecting plant-specific extension components.

Integrated simulation environment

A central concept of the new software system was the development of an integrated simulation environment for driverless transport systems, which can automatically generate a very realistic simulation model from the driving course design for a concrete plant. The control technology software that controls and schedules the vehicles in real



operation can be used directly to control the simulated vehicles without any adjustments. This means that an up-to-date, realistic simulation model is available at any time from the planning phase onwards, for example, for a time- and cost-saving "virtual commissioning" or for testing subsequent adjustments or extensions to a plant.

Proven many times in practical use

The software system developed, which is now successfully used in many plants of various sizes worldwide, already features numerous aspects that are now regarded as fundamental requirements for Industry 4.0 solutions. In the long-standing and sustainable cooperation with DS Automation, it was also possible to develop numerous innovations in several joint research projects.

Global coordination, local autonomy

For the area of driverless transport systems, the enormous progress made in the field of robotics in recent years will open up completely new possibilities in the future: On the one hand, small, agile, highly autonomous robot-like systems will be used more and more frequently for service and transport activities (small loads).

On the other hand, mature, low-cost sensor solutions and well-tested, efficient algorithms from the field of robotics will be integrated into driverless transport systems. One of the upcoming challenges to be solved is thus the networking and coordination of local and global intelligence into a functioning, optimally coordinated overall solution.



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LOGISTICS INFORMATICS

Intelligent solutions for logistics and production

Today, logistics means much more than just the transport or storage of goods. It is understood to mean the organization, planning and control of complex flows of goods. But also the reactions to short-term changes in the framework conditions in the supply network are becoming increasingly important, especially in the case of unforeseeable extraordinary circum-





stances. The design of logistics processes, their mapping and integration into existing systems in the context of digitization by means of information technology (IT) are decisive factors in the quality of services and products and thus ultimately also in the sustainable success of production and logistics companies.

Intelligent transport and traffic systems

The Logistics Informatics unit of RISC Software GmbH has versatile areas of expertise with which it makes a valuable contribution to ensuring the competitiveness of its customers in an increasingly dynamic environment. In the area of Intelligent Transportation and Traffic Systems, traffic data is dynamically collected with the help of modern sensor systems in order to create real-time traffic situation information. This data is processed and analyzed to create traffic simulations. Traffic forecasts derived from these can be used as the basis for efficient traffic management. In addition, mobility solutions are developed in areas such as Mobility as a Service (MaaS), shared mobility or multimodality, and solutions are created to optimize transportation and route planning.

Digitization of production and logistics

The planning and optimization of cross-company transport and material flows are covered in the topic area Digitization of Production and Logistics. The use of modern technologies for communication and interaction of systems enables

an efficient design of the supply chain as well as an optimization of capacity and resource planning. The focus is often on optimizations with customized tools for batch size and sequence planning problems, large-scale scheduling, disruption management, route, transport and tour planning, and much more. In addition, digitization efforts through Industry 4.0 are aimed at extensive and automated collection of large data streams (Big Data), from which valuable information and know-how (predictive and prescriptive analytics) can be obtained.

Natural Language Processing

Many companies also find added value in their unstructured data, which usually accumulates continuously in enormously large quantities in the age of digitization and automation. With Natural Language Processing (NLP), computers are able to process and generate natural language automatically and thus act as an interface between humans and machines. Regardless of whether fault messages in production processes are to be analyzed, information extracted from documents or products automatically suggested, NLP offers a wide range of industry-specific and cross-industry applications.

RISC Software GmbH meets these current requirements of modern data management and prioritizes the careful use of resources in the areas of logistics and production.

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Smart Mobility and Analytics

Modern research for the mobility of the future

The ever-increasing volume of traffic is one of the greatest challenges facing our society at present and will continue to be in the future. Congestion and related problems such as unplannable arrival times, longer travel and transport times, and the negative environmental impact can be reduced with the help of intelligent traffic systems and efficient mobility solutions. The Smart Mobility and Analytics (SMA) team of RISC Software GmbH has already gained many years of experience in the field of intelligent transport systems as well as transport telematics and has a broad range of expertise to drive efficient and sustainable developments in the transport sector. The focus is on the road transport mode, especially in the province of Upper Austria.

Traffic data processing

The research projects EVIS.AT and ITS Upper Austria promote the further development of the real-time traffic situation image for the province of Upper Austria, and RISC Software GmbH is working on its technical implementation. Due to the high number of high-quality traffic data from various sources (including Bluetooth, permanent counting

stations, floating car data), it is possible to provide a precise real-time traffic situation. In addition to this sensor data, traffic simulation is used to fill data gaps. The data obtained and the traffic simulation not only form an important basis for traffic information and forecasting, but also for further traffic planning studies. With the help of this traffic data, various customer and research projects as well as individually adapted transport and route planning solutions with mathematical optimization algorithms have already been successfully implemented.

Traffic and Artificial Intelligence

Artificial intelligence (AI) is playing an increasingly important role in road traffic, whether in counting vehicles using traffic cameras or in autonomous/automated driving. In the SafeSign research project, the focus was on safe traffic sign recognition for AI-based driving assistance systems. In this project, a comprehensive test data set for Austrian traffic signs was built and a dedicated traffic sign recognition system was implemented with the goal of making traffic sign recognition safely usable in Austria as well. In the themati-

cally-related AI Trust project, RISC Software GmbH is playing a leading role in the Upper Austrian strategy for testing autonomous driving and is thus shaping the future direction of research.

Sustainable transport

Sustainable mobility solutions have already been developed as part of various projects. The app LisiGo can forecast the optimal time to start a journey as well as the optimal route through the rush hour traffic in the Upper Austrian central region by means of routing based on historical and real-time data. As an implementation partner of the lead project DOMINO, RISC Software GmbH complements the Mobility-as-a-Service platform with a ride-sharing pool that connects commuters with each other in order to promote the switch to shared mobility.

The research fields in the area of Smart Mobility and Analytics are diverse and are becoming increasingly relevant for sustainable and safe mobility. With the broad positioning of RISC Software GmbH, sustainable mobility is being actively shaped here.



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HaltOpt - Stop optimization

A customized optimization solution to improve the forecasting of bus arrival times in the Linz area

Every day, hundreds of thousands of people take a seat on the regional buses of the Upper Austrian Transport Association (OÖVV) and are brought safely and comfortably to their desired destination on 34 million timetable kilometers. More than 970 buses on approximately 335 regional bus routes serve more than 10,000 stops throughout Upper Austria. The aim is to ensure that the population of Upper Austria has access to an optimal range of local and regional public transport services in terms of both quality and quantity.

Forecast arrival times

In the major cities, it is currently possible to read the forecast arrival time of the buses for the stop in question on the digital displays. For stops without these digital displays, you can fall back on the OÖVV INFO app or the Scotty app. Both sources display the latest information and are updated regularly.

The Oberösterreichische Verkehrsverbund Organisationsgesellschaft (OÖVG) commissioned RISC Software GmbH with the HaltOpt project, the aim of which is to increase the quality of the predicted arrival times of buses in the Linz area using the real-time traffic situation and thus the current travel times from the ITS Upper Austria (ITS-UA) and EVIS.AT research projects. For this purpose, the travel times from the current position to the next stops and between stops should be retrievable for specified courses.

This should help to provide even more precise arrival times for the population. For a high-quality and meaningful evaluation of the results, an evaluation will be carried out within the framework of the project, which compares the predicted travel times of RISC Software GmbH and OÖVV and compares them with the actual travel time. Based on this, a statement can be made about how much the forecast has improved.



High demands on the system

It is particularly important to have a highly efficient and scalable system that can forecast the arrival time of several hundred buses at the following stops in real time based on the current traffic situation. In doing so, a fast processing time has to be guaranteed despite a high request rate. To make things more difficult, the basic data, such as the street map of the graph integration platform GIP and the imported versions of the timetables of the ÖÖVV, are updated at different intervals, whereby special attention must be paid to the compatibility of these.

After completion of the project, there is the possibility of a roll-out to all courses of the ÖÖVV throughout Upper Austria through a follow-up project.



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Triply

Analysis of travel routes and determination of stops at large events

Existing traffic infrastructure often reaches its capacity limits during large events such as festivals, concerts or other events. For better planning of arrival routes and visitor flows (arrival time), Triply offers event planners a web platform of the same name, which uses historical booking data and participant numbers to make forecasts and provide alternative mobility solutions for transportation.

Floating Phone Data

Floating phone data (FPD) can be used to improve the forecast. This is anonymized movement data generated by the dial-up of mobile devices in radio cells. The mobile communications provider Drei offers a service called Motion Insights, which can be used to call up ready-made analyses for traffic, tourism, retail and events, as well as to provide Austria-wide FP data for individual analyses.^{1,2}

Festival and mobility planning

As part of a customer project with Triply GmbH, the Smart Mobility and Analytics team of RISC Software GmbH investi-


gated the suitability of FPD for festival and mobility planning using various data engineering processes. The FPD were provided by the mobile network provider Drei. The first step was to create an exploratory data analysis and visualization that was used to determine the potential and capabilities of FPD. With the help of the source-destination matrix and the temporal visitor flows, a model was then built that also takes into account the bias of average days on which no events take place. The following questions were answered in the context of festivals:

1. From which regions do the visitors come, which routes are chosen and where do the routes of as many visitors as possible overlap?
2. When do visitors from different regions leave, when do they pass the hotspots and when do they arrive at the event?

This made it possible to identify those hotspots where particularly large numbers of visitors converge in order to offer special event stops at these. In addition, some routes could be coordinated to avoid congestion on the way to and at the event.

1. <https://www.drei.at/de/business/digitale-loesungen/motion-insights/verkehr/>

2. https://elektro.at/wp-content/uploads/2021/03/Motion-Insights_Standortanalyse-in-Echtzeit.pdf



For the preparation of the models, data from three events in Upper Austria were analyzed:

- Clam Rock Festival 2019 (Burg Clam, June 28, 2019)
- Rock im Dorf Festival 2019 (Stausee Klaus, July 4, 2019)
- Kronefest 2019 (Linz, August 22, 2019)

Assuming that visitors mainly arrive by car, the floating phone data of Drei, which includes the postal codes of the starting points and the departure time, was mapped onto a traffic graph. The routes and hotspots identified in this process for the Burg Clam event example are shown in the figure below. The white dots on the map are the starting points of the routes. The blue circles shown in different sizes are the hotspots where the arrival routes of the visitors come together. The size of the circles depends on the number of visitors passing a hotspot. QGIS was used for the visualization.

Application in daily traffic and operational mobility

For the second question, the data from Drei for the festival day were analyzed with a temporal resolution of 30 minutes. This allows statements to be made about how private transport routes must be planned so that people are at the right place at the right time.

The model created is also suitable for analyzing daily traffic or company mobility. In the public transport network, it can be used to capture actual impacts of changes (e.g., construction sites, additional stops or accessibility), which are often very complex and frequently estimated on the basis of incomplete data. Visualizations of impacts can be created with a good data basis and support decisions. In the area of company mobility, the routes of the company's own employees can be superimposed, allowing better and more sustainable mobility to be planned.



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Success through algorithms

Customized optimization solutions for production and logistics

Optimal resource utilization is one of the most important factors for competitiveness. Despite the immense market relevance, practically applicable, out-of-the-box software solutions in the area of planning are rare and usually insufficient with regard to the complex requirements that often accompany them.

Customized planning software

High product diversity and growing complexity, which modern manufacturing structures bring with them, as well as rapid technological progress through Industry 4.0 lead to complex and changing requirements, especially for the planning and control of production processes. In this context, sustainable improvements in manufacturing processes, the constant reduction of energy and resource requirements, as well as the increase of adherence to delivery dates are often priorities. These goals can be achieved

through efficient planning and intelligent control. RISC Software GmbH generates considerable added value for its individually adapted software solutions. In the linking and further development of methods from mathematics and computer science and also in the cooperation with domain experts, the following focal points are set:

- Modeling of complex planning problems under consideration of available resources.
- Development of automated, multi-level and intelligent planning systems, which can make production processes significantly more efficient, flexible and cost-saving
- Use of both mathematical and heuristic methods as well as approaches from the field of artificial intelligence for the successful implementation of optimization requirements




Cross-industry application

Sustainable solutions have already been created as part of development projects with customers from a wide range of industries. Automated integrated batch size and sequence planning enables both the optimal use of production capacities and the increase of throughput quantities as well as the increase of flexibility and adherence to schedules.

In this topic area, an intelligent optimization module for solving large-scale, detailed planning tasks with dynamic constraints was created in cooperation with Industrie Informatik GmbH. In another project, an individual solution was developed for the optimization of freight wagon feed and removal and for the detailed planning of loading and unloading processes. Dynamic route planning, in which assembly lines are optimally supplied by dynamic route trains or delivery routes are ideally adapted to warehouse levels, also leads to significant increases in efficiency.

Further focal points are optimization tasks directly at the production machine, whereby optimal decisions are made during operation under real-time requirements. For example, for FILL Gesellschaft m.b.H. an algorithm for the optimization of glue laminated beams and their automatic layer formations was created in real operation at the production plant. Furthermore, for Sprecher Automation GmbH, an automatic side panel optimization for the ideal cutting pattern yield in the context of an automated saw line was developed.

For these and similar developments, in addition to RISC's own optimization library IBEX, the company also makes use of the wide variety of possible solution approaches, algorithms and tools and, if required, the latest mathematical software solutions. With the software solution of RISC Software GmbH, which is tailored to the individual needs in each case, it is possible to react quickly and efficiently to current market situations and to use these as new opportunities.



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RESINET

Resilience enhancement in energy networks

The current trend towards a growing share of renewable energy sources and the increased penetration of new electrical consumers lead to new challenges in the management of energy systems, especially with regard to the stability of energy networks (resilience). Driven by the energy transition towards the increased use of renewable energy, more and more fluctuating and volatile energy sources (wind power, PV systems, etc.) are entering the market and increasing the complexity of the ideal control of energy systems. The growing decentralization of the energy market also increases the challenge of balancing the fluctuating energy supply with the partially volatile energy demand.

Combination of classical methods with Artificial Intelligence

At the same time, modern methods of mathematics and IT, especially Artificial Intelligence (AI) methods, provide potentially suitable methods for the complex optimal control of energy systems. With these methods, the ever-increasing amounts of data in the energy sector can be studied, analyzed and used as a basis for learning systems in the

areas of load and generation forecasting, optimal control and balancing, and preventive maintenance and repair.

Three interlocking research topics can be derived from this, which focus on the use of AI and its linkage with classical methods:

- AI-based forecasting methods for load and generation forecasting
- AI-assisted simulation models
- Hybrid approaches for AI-assisted optimization methods for control and balancing regulation

The possible applications of these modern methods are manifold. For example, energy trading can also be supported with improved forecasts of energy prices.

Aims of the RESINET research project

In the grassroots research project RESINET, the focus is on the resilience of energy grids. Resilience is to be ensured even under the changing framework conditions, away from



Europäische Union Investitionen in Wachstum & Beschäftigung. Österreich.



centralized, unidirectional systems towards grids with a significantly higher share of renewable, fluctuating energy sources, increasing storage capacities in the grid interconnection and controllable loads. AI-based methods will be used to ensure the stability of the grids.

The goals of the RESINET research project are in particular:

- Development of a methodology for numerical assessment of power system resilience
- Development of a methodology to design the production topology for lowest possible vulnerability to grid outages as well as outage-minimized behavior during grid outages

- Development of dynamic, real-time control of generation and consumption devices for grid stabilization
- Development of load and generation forecasts in power grids and their integration into dynamic control systems
- Evaluation of the use of thermal and electrical energy storage systems for resilience enhancement of energy grids as well as the development of requirements for a suitable state sensor technology for these storage systems

This project is co-financed by the European Regional Development Fund (State of Upper Austria within the framework of ERDF-React).



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AnnaLyze

Intelligent data, text and image analysis

The digitization efforts of recent years enable extensive automated data acquisition, but this presents many companies with major challenges in data processing and analysis. Regardless of whether text, image or sensor data has to be generated and processed, the potentials can often not yet be sufficiently exploited.

AnnaLyze, the reference framework of RISC Software GmbH, was developed with this focus. Adapted to the individual needs and framework conditions in the company, AnnaLyze uses smart technologies in the field of data engineering and artificial intelligence (AI) to analyze (real-time) information as well as collected data pools from texts, images or sensor data, to create forecasts, to generate information automatically or to derive suitable optimization measures.

Data engineering as a solid basis for efficient use of data

Before analysis, data from a wide variety of sources is integrated and made usable efficiently. Data engineering is thus a prerequisite for the efficient use of data science, machine

learning (ML) and AI, especially in the Big Data area. Central activities here are:

- Data cleansing, e.g., by removing incorrect or incomplete data records
- Data integration from different sources
- Transformation of the data model for more efficient storage and improved data understanding
- Improved (faster) data utilization by accelerating queries
- Data preparation for AI, especially making available rich, cleaned training datasets
- Data and image analysis

Analysis of structured data and image data

The visual analytics, data analysis, and machine learning applications can be used to analyze structured data and image data. In the process, interrelationships, correlations and patterns are recognized, which are used, for example, for error and cause analysis as well as for continuous quality monitoring. The modules used and developed for this purpose include:

- Comparison of time series using a distance measure adapted for time series based on dynamic time warping
- Labeling Wizard, which allows users to quickly generate necessary annotations for subsequent training
- Anomaly detection within a set of time series
- Classifiers for time series and image data
- Time series prediction based on historical data as well as additional influences (covariates)
- SafeSign image analysis
- Text analysis

Processing unstructured text data with NLP

Natural Language Processing (NLP) enables computers to automatically process and generate natural language and act as an interface between humans and machines. More and more companies from various industries are turning to NLP solutions to better manage and utilize the accumulated, diverse forms of text in a variety of fields. Especially when there are recurring tasks to be completed, automation can be useful.

Examples are:

- Classification of documents: Documents can be automatically assigned to previously defined categories. This frees up resources that can be used for other tasks.
- Extraction of information from documents: Text documents contain any amount of information, but not all of it is relevant. Selectively extracting particularly important information from texts and storing it in a structured way can help to gain a better understanding of the text and enables further (automated) processing steps of the data, such as document classification.
- Assessing customer feedback: Keeping track of the current mood of your customers is often a difficult task. Sentiment analysis can be used to identify positive and negative feedback in texts (e.g., customer reviews). This can help to shorten response times to inquiries and to respond quickly and more specifically to the needs of customers.

The use of AnnaLyze guarantees a better understanding of your machine, text or image data. RISC Software GmbH meets the current requirements of modern data management and offers with AnnaLyze an individually customizable tool for knowledge generation of your data.



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What happened last night on the highway and why?

Database for the traceability of the circuits of the overhead displays on freeways

On Austria's freeways and expressways, people are familiar with the situation: Why is the overhead indicator showing a speed limit of 60 km/h right now? In order to answer such inquiries even for a point in time longer in the past - for example, in the case of inquiries by the executive - a modern data management system is to support ASFiNAG in the efficient handling of these questions. Decisions about speed or other warnings are largely made automatically by systems based on various sensor data. For example, in the event of increased traffic volume - measured by counting vehicles - a speed limit is displayed on the relevant road sections. In the event of rain or ice - detected by sensors - a warning symbol is displayed, for example. Or if the end of a traffic jam is detected, the overhead display indicates this a few meters ahead. Human intervention is, of course, also possible at any time.

Switching decisions on overhead indicators

The TRAPH project was launched in September 2020 to document these switching decisions and to make them retrievable and thus traceable over time. The aim is to store the related sensor data of the track and the switching decisions of the overhead indicators in a database.

Another goal, in addition to recording and retrieving the data in retrospect, for example, for emergency services, is to also find out which switching operations occur most frequently on which sections or which situations and actions lead to certain displays. Another use case is the evaluation of the local distribution of the switching operations. For example, an analysis in retrospect can be used to locate and defuse dangerous locations.

Technical implementation

Since the focus of the project was on the causal links and the traceability of the circuits, the project had as a goal to build a graph database to represent the data. This type of database is particularly suitable for storing such links, as it can represent and store this highly interconnected data using nodes, edges and connections.

In the final stage of development, it should be possible to trace the switching decisions for the whole of Austria back over several years. RISC Software GmbH transferred the data from the sensors, the measures and the switching decisions via a defined data streaming interface within the ASFiNAG network. The central research task included, on the one hand, the design of the data model for the graph database and, on the other hand, the efficient data transfer from different data sources as well as the storage in the graph database.

In addition to the mapping of the already existing causal relationships, especially time-dependent relationships pose a challenge for the data

modeling, since, for example, weather-dependent situations such as rain or black ice may well last longer and still be active at the time of query. In addition, it must be possible to restrict queries flexibly in terms of time in order to enable ASFiNAG to use the system efficiently.



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Factory of the future

Detection and prevention of production errors with data analysis and machine learning

How can production errors be found and explained, and how can this provide a better overview of production operations? RISC Software GmbH, together with the companies FILL Gesellschaft m. b. H. and Nematik Linz GmbH, addressed this task in the three-year Boost 4.0 research project.

The European project dealt with the development of large-scale industrial data experiments and the demonstration of data-driven linked smart factories. Together with the pilot partners, RISC Software GmbH achieves a better understanding of the machines by identifying causal relationships in the associated stored data. In order to be able to process the collected data efficiently, the design and implementation of a scalable data analytics system for Big Data in industry was defined as the main objective. Another use case was the establishment of an inspection system that uses machine learning to reduce manual inspections of production defects in the manufacture of cylinder heads.

Analysis of sensor data streams

The main tasks of RISC Software GmbH in the pilot of the mechanical engineering company FILL Gesellschaft m. b. H. focused on the selection of suitable machine learning and data analysis methods that are suitable for very big data and have the potential for parallel implementation. By integrating the results of Boost 4.0, the existing research infrastructure was extended by an architectural concept that combines Big Data technologies with semantic approaches. This facilitated the exploration and analysis of Big Data from heterogeneous sources (machine, product, process, and logging data) and enabled better data understanding. Using Dynamic Time Warping (DTW), a common method for comparing curves, it was possible to determine where exactly a delay/lead occurred during the execution of the machine program, as well as its magnitude. Furthermore, the log data of the machines were analyzed using Pareto analysis techniques as well as process mining approaches.



Quality assessment through image analysis

Together with the company Nematik Linz GmbH, the Nematik pilot project investigated how the quality assessment of castings could be strengthened by data analysis. To this end, machine learning was used to automatically reassess castings on the basis of computed tomographic X-ray images (XCT images) previously identified as defective by an XCT inspection system. The expected impact is therefore an optimization of the quality assurance process and the reduction of personnel resources at Nematik Linz GmbH: Fewer rechecks by XCT experts have to be performed.

Boost 4.0

The BOOST 4.0 project "Big Data Value Spaces for COmpetitiveness of European COnnected Smart FacTories 4.0," was funded under the European Union's Horizon 2020 research and innovation program under grant agreement No. 78073 and successfully completed in 2020. It is

the largest European initiative for Big Data in Industry 4.0 and has a budget of 20 million euros with an additional private investment of 100 million euros.

The consortium consisted of 53 companies from 16 countries, all coordinated by Innovalia Group. This initiative aimed to advance the development of the European Industrial Data Space in order to improve the competitiveness of the European automotive industry. Another goal was to help the manufacturing industry adopt Big Data in the factory and provide the industry with the necessary tools to generate maximum value from the industrial value of Big Data.

More information at: <http://boost40.eu/>



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Prescriptive Analytics

Better and transparent decision-making

For companies that already have a large database, prescriptive analytics offers the opportunity to generate additional value from the data already available by incorporating the insights gained from the data into planning. Companies that do not yet have end-to-end data collection or do not yet use their data for such tasks have the opportunity to gradually increase the value they derive from their data. The steps from descriptive to prescriptive analytics build on each other and already in the diagnostic analytics valuable insights can be gained (together with the company experts). Then the next steps can be planned in order to successfully shape the path to prescriptive analytics.

From data collection to prescriptive analytics

Digitization in recent years has created the basis for companies to continuously collect and store data on their processes and operations in a structured manner. To create added value, companies must make the best possible use of this data. For example, forecast models are created from

the collected data in order to be able to estimate future developments, events or conditions. These can be models for sales forecasts, wear and tear of tools in production, customer requirements, inventory levels, traffic-dependent travel times, etc.

By combining the forecast models with optimization models (for calculating optimal decisions), different scenarios can be automatically calculated and compared. This provides those responsible with a solid basis for making optimal decisions. The transparent basis for decision-making guarantees that the decisions made are always comprehensible and can be argued.

Use cases

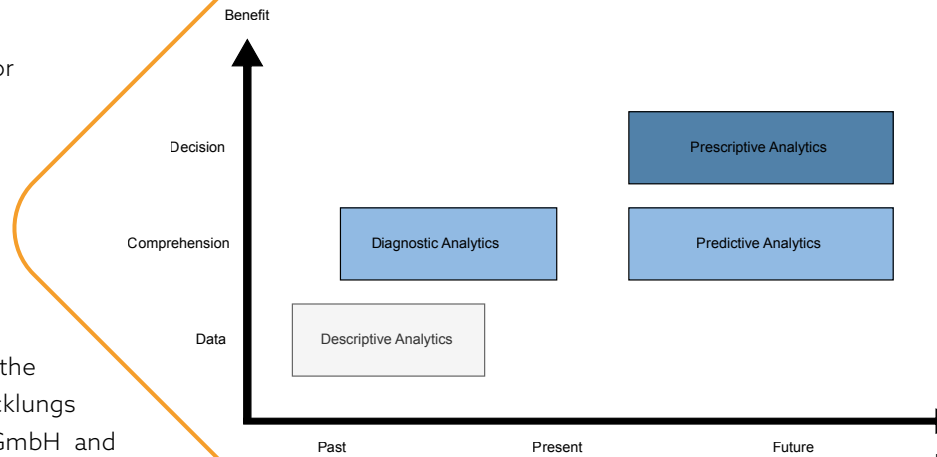
There are many different application areas for prescriptive analytics, such as the following:

- Support in production and resource planning e.g., to determination of remaining capacity

- Automation of the ordering process, e.g., for automated control of order details
- Evaluations of factors influencing sales or production figures

Bundled research competence

The basic research project Secure Prescriptive Analytics is funded by the province of Upper Austria and bundles the competencies of the project partners FH OÖ Forschungs und Entwicklungs GmbH, Campus Hagenberg, RISC Software GmbH and Software Competence Center Hagenberg (SCCH) in order to establish and expand this research area in the years 2022-2025. An open source platform is being developed that will make the results of the research available to industry. Companies can then use these methods directly or supervised by a research partner for their own problems or tasks. This provides low-threshold access to state-of-the-art methods for industry.



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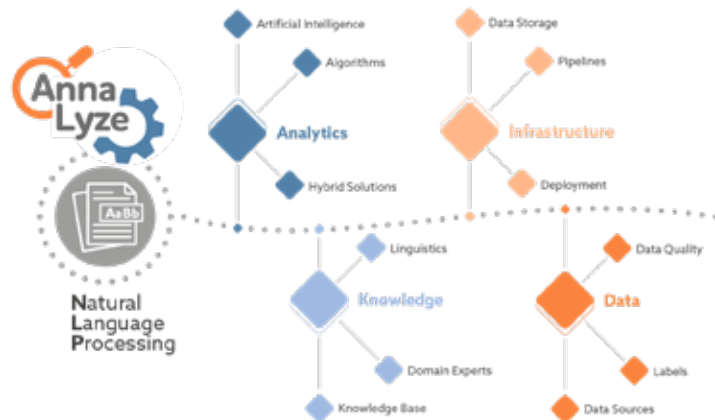


Natural Language Processing Solutions

Artificial intelligence as an interface between human and machine

Language is omnipresent and we encounter it in many different facets both in our private everyday life and in our professional environment - written, spoken and communicated in different languages by humans, but also analyzed, processed and synthesized by machines. With Natural Language Processing (NLP), computers are able to process and generate natural language in an automated way and act as an interface between humans and machines.

As an application area of Artificial Intelligence (AI), NLP is used whenever monotonous processes or frequently recurring tasks in text processing are to be automated, subsequently optimized and integrated into a higher-level framework. In this way, errors can be minimized in various areas, processes (partially) automated and savings achieved. Whether fault messages in production processes are to be analyzed, letters are to be filed in a structured manner or products are to be suggested automatically, NLP offers a wide range of industry-specific and comprehensive application possibilities.



Innovative NLP technologies

RISC Software GmbH supports its customers with its many years of practical experience when it comes to the development of individually tailored, AI-supported solutions. Innovative NLP technologies are used, which are based on four fundamental components:

- Analysis methods specifically selected for the problem at hand
- Strong integration of domain know-how
- Tailored infrastructure solutions
- Comprehensive management of (Big) Data

Core competencies

The core competencies of RISC Software GmbH are as follows:

Information extraction – Searching for keywords: Particularly relevant information is extracted from text documents and stored in a structured manner. This enables a better understanding of the text and further (automated) processing steps.

newsadoo



Reference project Newsadoo: "Newsadoo - All the news you want" - allows users to access news articles from numerous sources and offers relevant news as well as news personalized according to interests. In the background, NLP is used to transform unstructured text data into structured, analyzable content.

Document classification - Sorting by hand was yesterday: Manual sorting of documents can be very time-consuming and labor-intensive. By automating the classification process, documents can be automatically sorted into predefined categories. Freed-up resources can be used for quality control and other tasks that can only be performed by subject matter experts.



Reference project ACT4: In an expansion stage of the existing platform solution ACT4 of Compliance 2b GmbH, RISC Software GmbH is developing a trustworthy AI component together with the company, which on the one hand supports whistleblowers in submitting the report and, on the other hand, should enable the responsible clerks to process the reports more efficiently and in a less error-prone manner. The system will automatically

derive information (e.g., notification category or roles) from the textual notifications and compare it with already structurally recorded data in the form of a plausibility check.

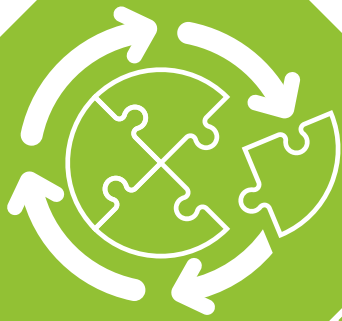
Sentiment analysis - How emotions become tangible: Keeping track of the current mood of your customers is often a difficult task. With the help of sentiment analysis, positive and negative feedback in texts (e.g., customer reviews) can be identified and help to shorten response times to inquiries and to respond quickly or more specifically to the needs of customers.

Reference project Intelligent Twitter Analysis: Are positive emotions in tweets about listed companies related to their share price performance? Sentiment analysis can be used to analyze a text in terms of sentiment (positive, negative, etc.) and evaluate how much information is actually contained between the lines.



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DOMAIN-SPECIFIC APPLICATIONS

Agile software development for Data and Process Management

Together with partners from research and industry, the Domain-specific Applications unit of RISC Software GmbH develops sustainable solutions that are individually adapted to the respective requirements. On the one hand, RISC Software GmbH acts as a professional implementation partner for





software development and, on the other hand, it supports its partners through coaching and training in the introduction and consolidation of agile methods.

Individual software development

Companies in industry and research are continuously confronted with the development, selection and operation of software in order to be able to appear on the market efficiently and effectively. A pool of existing software products is available, which may fit the current needs or can be adapted accordingly. Nevertheless, homogeneous integration into an existing system landscape is often difficult and may not be guaranteed in the long term. Likewise, the replacement of individual software products within a system can prove to be extremely costly. The size of the company is independent of this.

Corporations have correspondingly large system landscapes, while start-ups are often confronted with software

products that do not fit their business idea. This is where the individual development of software products comes in, which can be optimally integrated into existing systems, continuously maintained and adapted accordingly.

Professional project workflow

By using state-of-the-art technologies, the Domain-specific Applications unit generates flexible solutions that can be used for many application areas. Tailored software solutions grow with projects and always adapt to new requirements. A professional and flawless project flow is ensured through the use of agile methods. This is achieved through the use of certified and project-experienced Agile coaches, who enable a smooth collaboration of software engineers, data scientists, mathematicians, UI designers, project managers and users.

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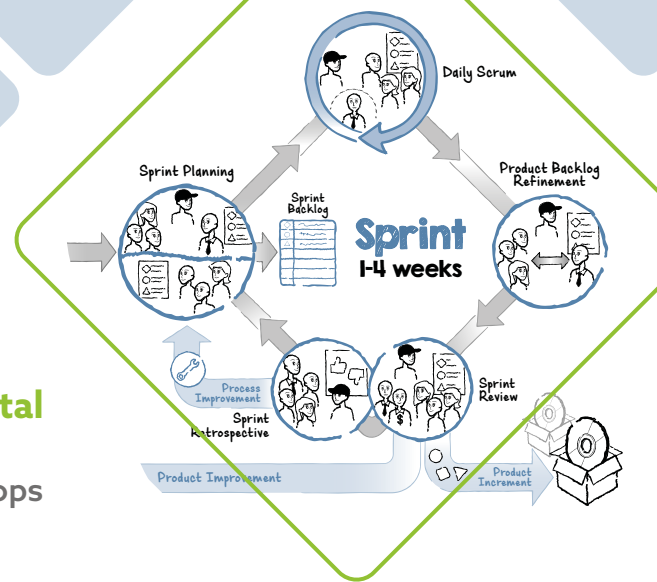


Agility based on the development of a B2B portal

Flexible software development with many feedback loops

The processes of software development are complex and constantly changing. RISC Software GmbH has reacted to these developments and adapted: Agile methods are now standard in the implementation of software development projects. As a result, RISC Software GmbH's customers benefit from, among other things, greater flexibility in the definition and implementation of project content and a targeted and value-creating development supported by regular feedback loops and direct communication. An agile process model that combines some of these methods in a common framework is Scrum. In recent years, RISC Software GmbH has already implemented several extensive projects with Scrum, including a large B2B portal in retail.

In this project, an existing portal was replaced by a new one. At the start of the project, it became clear relatively quickly that the existing system was highly complex, had an extensive feature set that was not fully known at the beginning, and had many interfaces to other systems. For these reasons, close cooperation between the customer and RISC Software GmbH was necessary.



Product Owner and Scrum Master

The agile project process, as applied in this project, is as follows: At the beginning of the project, a Product Owner (PO) is appointed who, together with the stakeholders, defines a vision for the project and is primarily responsible for feature planning and prioritization. She/he is supported in this by a Scrum Master from RISC Software GmbH. The Scrum Master is responsible for designing and implementing the Scrum workflow and supports the Product Owner and development team in adhering to it.

All parties strive to act as a joint team and work closely together, because good communication is crucial to the success of the software project. The features created and prioritized by the PO are regularly discussed together with the development team in order to obtain a common understanding of the requirements and the purpose of the individual features through direct exchange. These so-called "refinements" create clarity on both sides and increase efficiency in the implementation of the features.

Refinements and Sprints

Both the refinements and the implementation of the features are carried out in one- to four-week iterative development cycles ("sprints"). PO and stakeholders can thus regularly evaluate completed features and provide feedback. This ensures that the implementation of the project vision meets the expectations of the stakeholders. In addition, the project process and collaboration are also regularly inspected and adapted. In a "retrospective" at the end of each sprint, the team can openly address any problems and hurdles and set measures for improvement. Daily meetings ("Daily Scrum") during the sprint help the team to align the current work packages, to immediately point out problems and obstacles in the development and to constantly keep the focus on the completion of the selected features. The constant feedback iterations and improvements to the product not only increase the quality of the end result, but also help the development team become more motivated and eager to work.

After the completion of the B2B portal, it can be said that the inherent flexibility of Scrum was extensively used and appreciated by the customer. The agile approach prevented tedious and often very costly rework in advance. Thus, a plat-

form was developed within the scope of this project that meets the real requirements of the users and thus facilitates their daily work.

Value-creating project management with agile methods

Agile methods and process models can, of course, not only be applied to software development processes. RISC Software GmbH also uses agile methods in the area of optimization and data science, for example, in order to offer its customers the most value-creating project execution possible. Over the years, RISC Software GmbH has gained a great deal of knowledge and experience in the area of agility. As part of the RISC Agile Academy (see page 20), certified coaches share their experience and knowledge of agile working with companies.



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GS1 Austria Workflow

Information system to comply with a standardized workflow

GS1 Austria offers its customers user-oriented standards and services for identification, information and processes to optimize costs and quality. With GS1 Sync, a central item master data service is offered as a clearing house for the Austrian consumer goods industry. In order to meet the high standards in the food sector (such as the Food Information Regulation, or LMIV for short), strict controls and compliance with a precisely defined workflow are required. The quality check of the food data is carried out manually by specially trained employees of GS1 Austria.

Web-based workflow system for quality verification

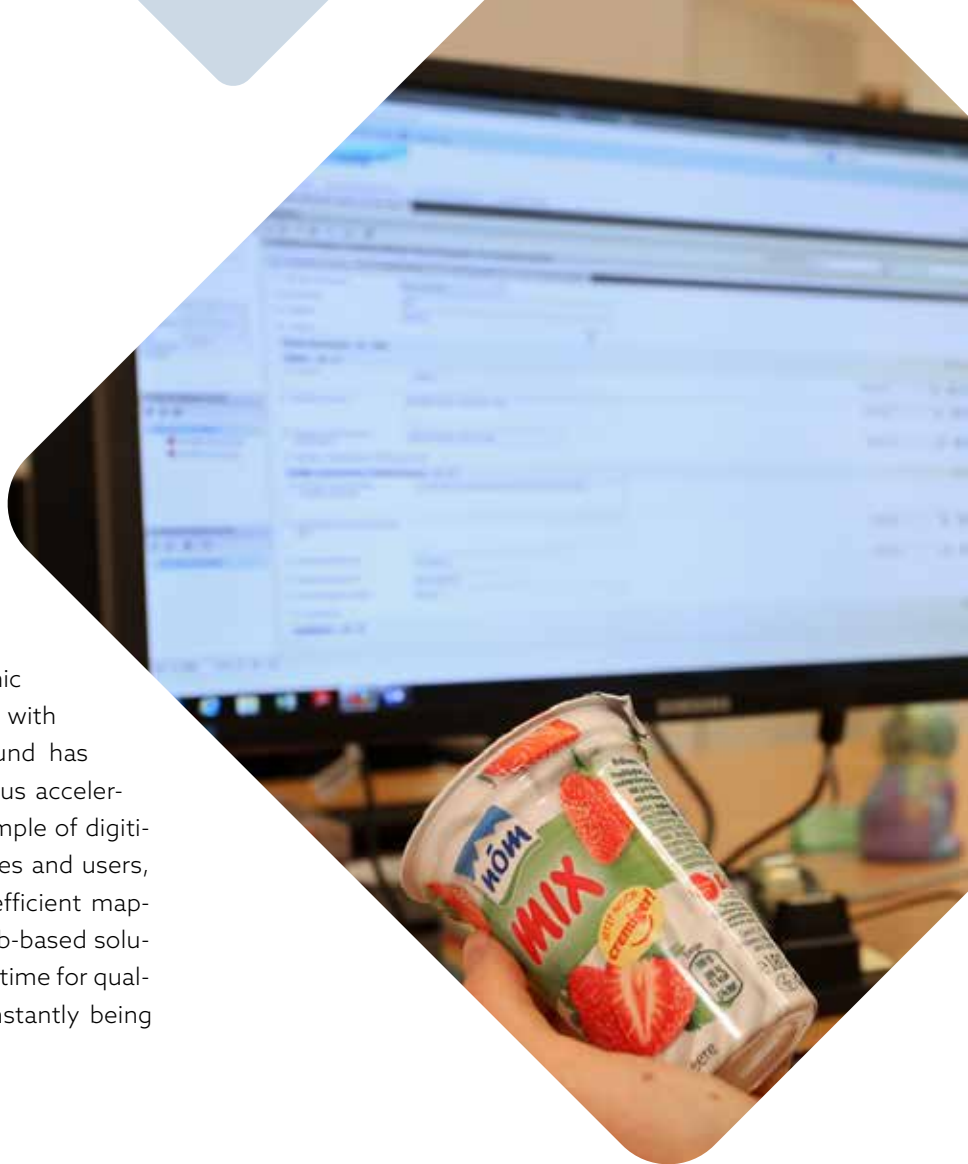
Before the joint project with RISC Software GmbH, the entire workflow, including communication with customers, was handled manually. This workflow is now mapped

with the help of a web-based workflow system developed by RISC Software GmbH. GS1 Austria employees log in via the multi-user web platform. There they can see all the inspection orders for which they are responsible and can process them in clearly defined processes implemented in the system.

The food data is automatically imported into the workflow system for GS1 Austria. This provides GS1 Austria employees with an uninterrupted workflow via a common platform, which contains all the necessary steps of the quality check, from control and confirmation to the release of the product data. Meanwhile, automatic e-mails keep customers up to date at all times. File management, reporting and seamless change tracking are also handled in this overall solution.

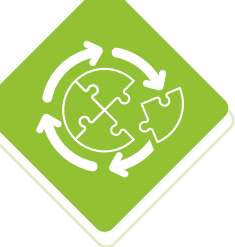
Value-creating collaboration between people and software

The actual core task of quality inspection remains unaffected: The comparison of the data on the product label with the electronic data is carried out at a very high speed and with great accuracy. The entire process all around has been digitized or partially automated and thus accelerated and optimized. This is a successful example of digitization that does not compete with employees and users, but embodies a profitable interaction. The efficient mapping of the workflow with the help of the web-based solution has significantly reduced the turnaround time for quality inspections. The workflow system is constantly being expanded with new features.



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Salinen Austria

Generic web application for data and process management

Salinen Austria AG is Austria's leading manufacturer of salt products with an annual production of 1.1 million tons and sales of 100 million euros. More than 450 employees work to ensure that Austria is supplied with a wide range of different products, from table salt to salt for chemical use, chemically pure salt for the medical sector and road salt for winter road clearance services.

In order to be able to keep track of and manage this variety of products and the associated wealth of information, Salinen Austria AG relies on a generic web solution from RISC Software GmbH. It allows the operator of the system, in this case the IT department of Salinen Austria AG, to adapt to changed requirements independently and without programming at any time. On the basis of this generic software, several web applications were implemented that support the processes of Salinen Austria in various use cases.

Product database

Salinen Austria AG has several thousand products in its portfolio. The associated data (chemical properties, nutritional value tables, printed matter, etc.) are distributed in several database systems and can also be found in a wide variety of files.

In order to standardize this diversity, all this data is brought together in a central product database. In this way, the necessary information can be made available to the various users on a uniform platform. The information collected here can also be integrated into the other software solutions developed on the basis of the generic web solution.

Purchasing Management System

The web-based central purchasing management system offers uniform handling of purchasing processes throughout the Group. In terms of operation, the system is similar

to familiar online stores, allowing authorized users to make purchases for the company. The complex processing in the background remains completely hidden.

Carrier portal and B2B portal

In these web platforms, users receive a real-time overview of all orders assigned to them from the time of the order to the delivery of the goods. Users are continuously kept up to date on the status of their orders and can intervene in the processes within the framework of certain rules and add internal meta-information to the orders. In addition to the pure display of order data, numerous workflows have also been implemented.

In the B2B portal, customers can conveniently enter new orders in a web store. By checking all entries against master data and rules, potential errors are identified and corrected by the customer before the order is transferred to their enterprise resource planning (ERP) system. This means that fewer manual corrections are required after the order has been placed, which reduces the workload on the back office and speeds up order processing.

In the carrier portal, hauliers can choose a free time slot for loading the truck. This close cooperation between the salt works and the freight forwarders avoids peak loads during loading and thus reduces the waiting time of the trucks. All workflows and changes to data are logged to ensure that the processes are traceable. As part of these processes, employees and customers are informed by e-mail about important processes and any problems.

Standardized development and consistent operation

By using a generic solution as the base technology for all implemented systems, the development is not only based on a stable code base. In addition, numerous cross-application components (data model, rights and user management, automatically generated UI elements, REST interfaces, data import and export modules, data evaluation functions, etc.) are available for all web applications. This leads to standardized development and consistent operation of all systems based on it.



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SecuReveal

A whistleblower system for legally relevant facts

The term whistleblowing has been on everyone's lips at least since the Edward Snowden case. The former employee of the U.S. National Security Agency (NSA) published classified documents in 2013 and thereby gained controversial worldwide fame. The topic of whistleblowing is also becoming increasingly important in Austria. For example, since August 2016, listed companies have been legally obliged to offer whistleblowing systems for their employees. In 2019, this obligation was extended to all companies with more than 50 employees or annual sales of 10 million euros by means of an EU directive.

The Austrian product SecuReveal enables whistleblowers to report legally relevant irregularities in their own company. Examples of legally relevant irregularities include insider trading, bribery, corruption, fraud and accounting fraud. As a result, the company's compliance officers can enter into a secure dialog with whistleblowers to obtain further information. If desired, whistleblowers can maintain their anonymity. SecuReveal was developed in careful collaboration between Responsible Business Solutions, a sub-

siary of Austria's largest law firm Wolf Theiss, Red Puls IT & Security Solutions GmbH and RISC Software GmbH as a technology partner. All partners contributed their extensive and long-standing expertise to jointly design and operate a larger whole.

High demands on the safety concept

Within RISC Software GmbH, great attention was paid to IT security during the development of SecuReveal right from the start. For example, communication between users and SecuReveal is encrypted throughout, and messages recorded in the system are also stored in encrypted form. A sophisticated security concept ensures that only authorized persons have access to the respective messages. Even for developers and operators of SecuReveal, access to messages recorded in the system is excluded thanks to encryption.

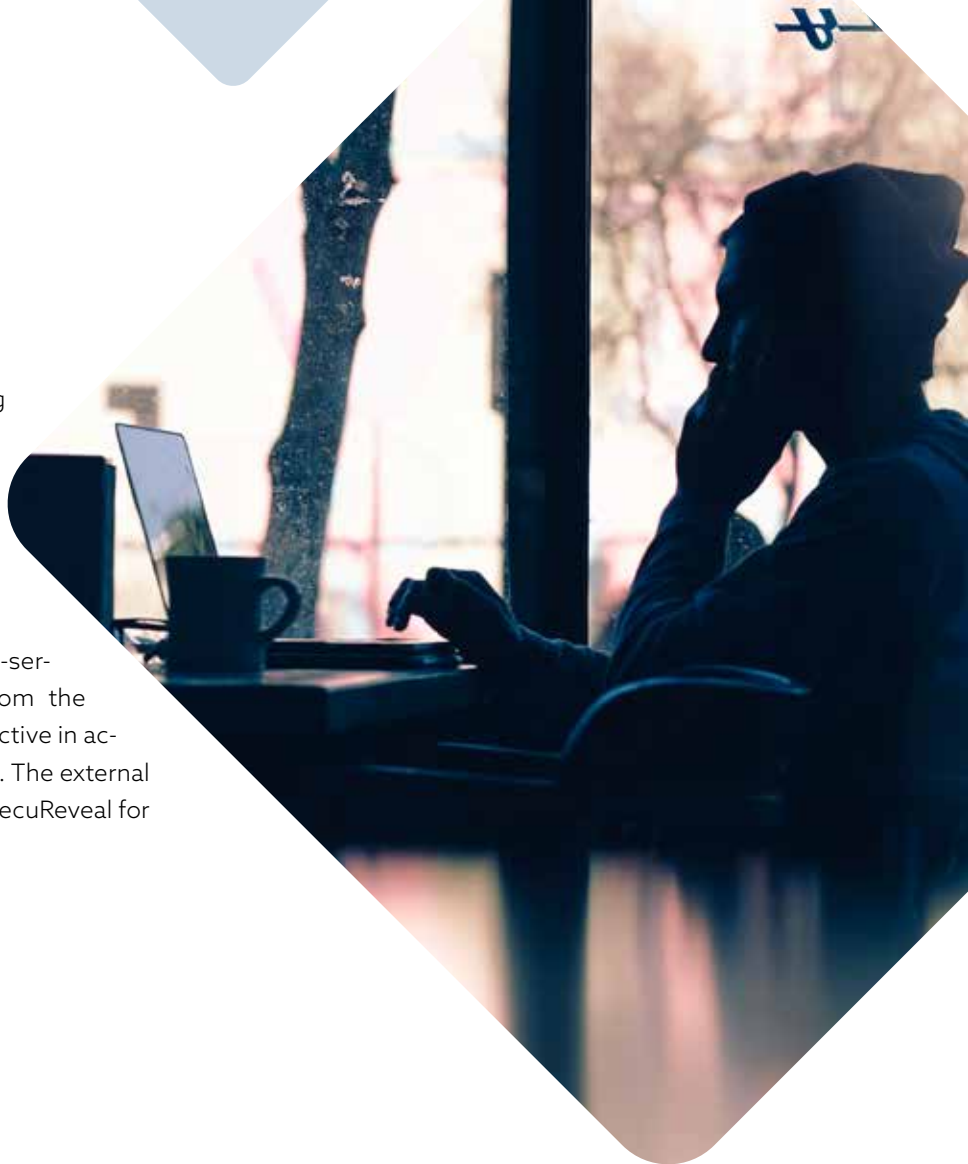
In addition, adequate processes and roles were defined, along with the associated rights and obligations, and clearly and comprehensibly distributed among the partners. Ap-

appropriate documentation of activities during development and operation ensures sustainable and secure conditions, which are taken for granted by the partners in such a sensitive system.

Software as a Service

SecuReveal is a customizable software-as-a-service solution: companies are supported from the outset from both a legal and technical perspective in accordance with their wishes and requirements. The external operation strengthens the confidentiality in SecuReveal for whistleblowers and compliance officers.

Further information at www.secureveal.com.



Wolf Theiss

RESPONSIBLE BUSINESS SOLUTIONS GMBH

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MEDICAL INFORMATICS

Highly specialized software for modern medicine

For 20 years now, the Medical Informatics Research Unit has been successfully dealing with the systematic processing of data, information and knowledge in medicine and healthcare. Scientific methods and tools from computer science, mathematics, physics, economics and medicine are combined to create sustainable solutions for patients, physicians and the healthcare system.





Information technology in medicine

It is the mission of the Medical Informatics research unit to support medicine with information technology methods, especially through improved diagnostic methods and optimized healthcare processes. Our vision is to collect and process multimodal medical data for personalized, evidence-based diagnosis, treatment and prognosis in order to generate new knowledge together with medical professionals. In doing so, innovative technologies for the medical field are researched, developed and used to ensure the health care of the population, to increase the quality of care and to sustainably improve individual patient care and patient safety.

Success through collaborations

This success is made possible by long-term cooperation with regional, national and international medical partners, such as the Kepler University Hospital Linz (Med Campus III and Neuro-med Campus), the Medical University of Graz, the BG Klinikum Unfallkrankenhaus Berlin (D) and the Shriners Hospital Galveston (US). An innovative training and planning platform for neurosurgeons is currently being developed from the collaboration with the first-mentioned in order to simulate complex brain interventions.

Application of the most modern methods

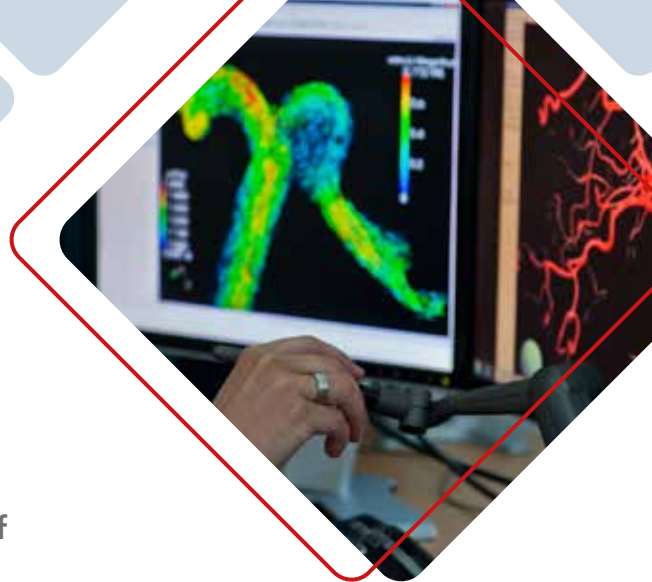
The strengths of the Medical Informatics research unit lie in applying state-of-the-art scientific methods to solve medi-

cal problems. The many years of experience, the know-how and the scientific excellence of the employees as well as the good networking with partners from research, industry and medicine form a central basis for sustainable research and development.

Broad field of activity

The field of activity ranges from basic research to clinically applicable software. In particular, methods in the areas of medical image analysis and segmentation, medical modeling and simulation, and medical data analysis and prediction are used to solve complex medical problems. The results of this intensive and continuous research are not only exploited together with partner institutions in the form of medically relevant solutions, but are also presented to the professional audience at international conferences.

The combination of non-university research, entrepreneurial innovation and enjoyment of new challenges make the Medical Informatics Research Unit of RISC Software GmbH a successful and ambitious cooperation and research partner for national and international projects. The projects of the Medical Informatics Research Unit are financed by research funding from the State of Upper Austria.



Medical Image Processing, Modeling and Simulation based on Artificial Intelligence

AI-based image processing, modeling and simulation of medical data

The research area "Medical Image Processing, Modeling and Simulation based on Artificial Intelligence" (MI-MAS.ai) covers a cross-section of highly dynamic research topics, which are becoming increasingly important in medical application fields, not least due to current technological advances.

Medical image analysis and image segmentation

Medical image data are used in a variety of forms for diagnosis, treatment planning, monitoring of interventions and observation of changes in condition and documentation. Common image modalities range from 2D images (X-ray, wound photos...) to 3D scans (computed tomography, magnetic resonance imaging, digital subtraction angiography...) to videos (2D+t, 3D+t), which also capture the temporal course.

In order to process these multimodal image data for medical diagnosis, treatment and documentation purposes, the Medical Informatics Research Unit is developing various

methods for image analysis and image segmentation. Using artificial intelligence-based methods, these image data are registered (overlaid) in order to subsequently segment (extract) patient-specific anatomical structures, such as blood vessels, tissue or skin. These segmented anatomical structures form the basis for medical models and simulations based on them.

The success of machine learning methods for registration and segmentation depends largely on the number and quality of available training data. Especially in medical application fields, data with corresponding ground truth are often missing or they are not available due to data protection reasons. Therefore, research in this area also focuses on methods that allow an easy and interactive generation of a ground truth. These methods include CycleGANs to generate synthetic training data, One Shot Learning to generate a multitude of training data from one data set by means of augmentation, Transfer Learning, whereby already learned knowledge models are used for similar problems,



or Domain Adaptation to adapt learned models to new data distributions.

Medical modeling and simulation

Modeling is generally understood to be a simplified representation of reality. In the medical context, models are strongly oriented towards clinical relevance, applicability and available data. Models range from 3D body surface models to blood flow models.

In many medical fields, such as burn medicine, chronic wound management or forensics, the affected body surface of patients is an essential diagnostic basis. In the research focus, virtual 3D patient avatars are created, which match real patients as closely as possible and thus enable objective diagnostics and medical (progress) documentation. For example, the size and position of chronic wounds can be precisely determined and the success of the therapeutic approach can be assessed over time.

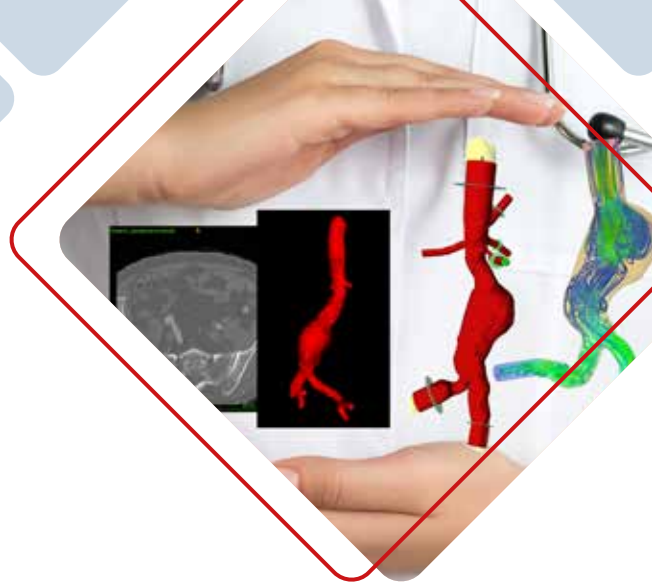
Biomechanical simulation can be used to reproduce processes in the human organism (e.g., blood flow). Based on registered and segmented medical image data,

methods for modeling anatomical structures (blood vessels, tissue, skin...) are used, computational grids (meshes) are created and material properties (elasticity, viscosity...) are determined. Based on the model, geometric features (e.g., maximum diameter of a blood vessel) as well as simulation-based features (e.g., mechanical stress of a vessel wall) can be calculated.

These simulations allow medical experts to make or evaluate diagnoses and treatment decisions using quantitative measures. For example, blood flow simulation can be used to determine the risk of rupture of an aneurysm and to evaluate the effectiveness of interventions in the vascular system (e.g., clipping of aneurysms, insertion of a stent-graft). These models and simulations are used, for example, in simulators for the training of physicians and for the realistic training of medical interventions.

Medical data analysis and prediction

A key success factor for the application of machine learning in medicine is the trust of physicians and patients in the database and the prediction models derived from it. This trust is based on methods for validating the data, interpreting the model predictions and analyzing deviations. By making →



→ these methods available and usable in a data processing and analysis framework that encompasses the entire data processing pipeline, the Medical Informatics Research Unit supports physicians in clinical practice.

The development of the necessary data processing structures takes place within the framework of selected example scenarios. Application areas include transfer management in the intensive care unit, optimization of the Manchester triage system in the emergency room, optimal application of blood reserves, and prediction of cardiac instability.

The focus is on researching a generic and easily configurable data processing chain for proven and latest methods in order to meet future requirements. In addition to structured data, image, video and signal data as well as combinations of different data modalities and specialized feature extraction serve as the information and data basis.

The research focus is on interactive data analysis of different modalities with a focus on interpretability and traceability of single data or data groups in terms of "Explainable AI." Especially in medicine, transparency is of particularly high importance for the acceptance of AI-based software.

Interaction of these research fields

The research fields of the Medical Informatics Research Unit are very closely related. Medical image data often form the basis for modeling, models in turn form the basis for medical image processing and information extraction as well as for the simulation of processes in the human body. The basic technologies and methods used in the research fields also show a variety of overlaps. GPU-based (Graphics Processing Unit) parallel computations have enabled the triumph of Deep Learning in image processing in recent years and at the same time provide the basis for the simulation of processes in the human body.

However, physiological interactions require corresponding models of anatomical structures, which are extracted from medical image data using segmentation methods. Registration - the computation of a transformation that brings multiple data sets (model, image, volume) into geometric

agreement - enables the use of multiple data sources as well as the transfer of information between different data domains. Information extraction is performed in different ways in all research fields. The following medical application examples illustrate the interrelationship of these research fields:

Rupture risk of aneurysms: Aneurysms are diagnosed in CTA (computed tomography angiography) scans. Segmentation of aneurysms and blood vessels is used to create a volume model (mesh) for blood flow simulation. The simulation allows calculation of pressure and vascular stress. For a cohort of patients (e.g., aneurysm patients over the last ten years), these characteristics can be used to determine the risk of rupture using machine learning-based data analysis and to select an appropriate treatment strategy based on this.

Burn classification: Patients with burn wounds are initially treated in the emergency room. Using medical modeling methods, a virtual 3D body surface model is adapted to the patient using an RGB-D scan. Burn depth is classified using image analysis methods. The wounds (extent and depth) are documented on the body surface model. The temporal progression of the wound due to subsequent treatment is documented on the body surface model and can thus be used to improve the treatment of future patients.

The common goal of all work is the further spread of individualized and evidence-based medicine. To this end, current research methods must be further developed at an early stage in cooperation with medical experts. This is the only way to ensure that current methods are also used in clinical practice in the medium term for the benefit of patients.

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OMEDA

Acquisition, validation, processing and visualization of medical research data

The research focus "Ontology-guided MEdical Data Analysis" (OMEDA for short) comprises generic software systems for the acquisition, validation, processing and visualization of complex medical research data as well as Medical Data Analytics in the broadest sense.

Involvement of domain experts

The primary goal is not to develop new analysis algorithms, but to answer the question of how to allow domain experts (medical researchers, clinical process analysts, QM managers...), who are usually not IT and data analytics experts, to extract knowledge from their data.

Guidance-based data analysis in medicine

The aspect "Guidance in medicine" is considered. In the Systems and Technologies field of action, human-machine interaction is examined. In addition, algorithms and methods for simple and secure use by domain experts will be developed at the technical level managers.

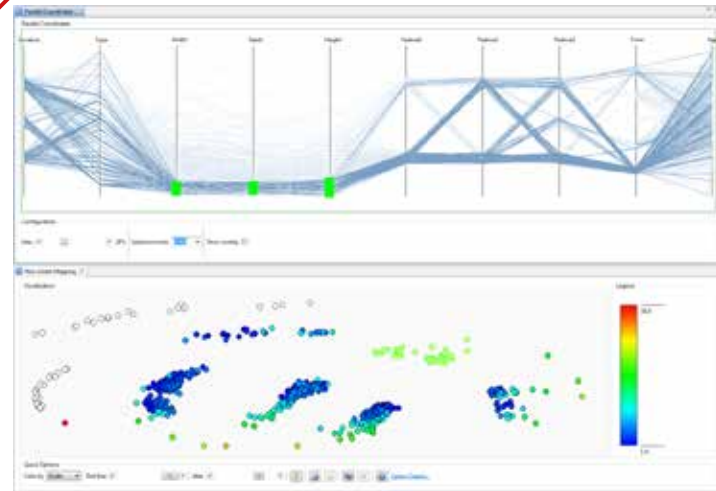
The content-related research work includes, for example, statistical analysis methods and corresponding controlled user guidance as well as generic data processing processes and data models.

Medical Data Analysis

Concepts are emerging in the context of innovation-driven medicine and human-machine symbiosis. Interactive visualization methods can be used to extract new knowledge from large, complexly structured and heterogeneous data sets ("Doctor-in-the-Loop"). The main aspects are the preparation and processing of medical data as well as the safe application and interpretation by medical researchers. The goal of the Doctor-in-the-Loop concept is to incorporate the domain knowledge of the medical experts during the analysis process (e.g., via automated preselection of analysis methods and interactive machine learning) and to immediately return the results to the domain experts. In this way, the domain experts can correctly interpret this knowledge

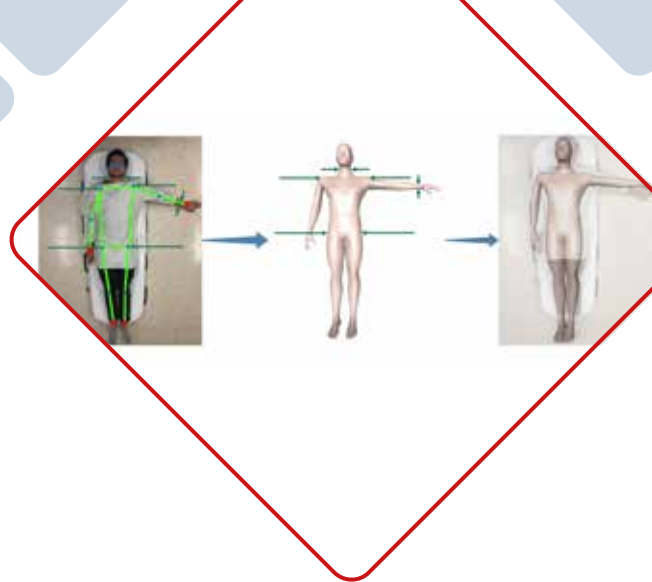
and integrate it into their knowledge pool. Techniques such as visual analytics are used for this purpose. Interrelationships and differences in the data can be captured more quickly and easily visually than via complex numerical results.

Metrics and distance measures serve as the basis of clustering algorithms with the intention of generating a meaningful representation of the data. The basis for this lies in the clean preparation and validation of the collected data in order to obtain reliable analysis results with a good selection of features (feature generation) and with verified preconditions regarding the data and applied methods. The vision of the research focus is to make these topics available for medical questions based on concrete research hypotheses. The aim is to create a system that can answer a wide variety of medical questions on a generic basis across the entire processing chain of data analysis. In symbiosis with domain experts, patterns, correlations and medical hypotheses will be revealed and new knowledge generated.



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Surface 3D

Optimization of burn treatment and documentation

In burn medicine, the percentage of burned body surface area out of the total body surface area of patients is a crucial parameter to ensure adequate treatment and therapy. However, estimating total body surface area is challenging due to individual body size and body proportions. Inaccurate estimates of burn extent can lead to suboptimal medical decisions with significant consequences for patients. With the help of Surface 3D, a precise calculation of burn size is made possible, thus ensuring patient safety and supporting medical staff in everyday clinical practice.

In close cooperation with numerous medical partners, the medical informatics research department of RISC Software GmbH has been developing objective 3D methods for optimizing burn treatment and documentation for around 20 years. One of the central results of this research work is Surface 3D - an interactive, web-based tool for the highly precise annotation of burn wounds on patient-specific 3D body surface models. In addition to automatically deter-

mining the degree of burn and calculating wound size in real time, Surface 3D enables comprehensive documentation of wound healing over time.

Patient-specific 3D models

In Surface 3D, 3D base models from a model collection can be adapted to patient-specific parameters such as gender, weight or height. These models enable continuous documentation of the burn wound.

Automatic pose adjustment

To enable efficient use in everyday clinical practice, automated pose adjustment of the model was implemented. For this purpose, the location and position of the joints are extracted from a single RGB image using machine learning algorithms. The exact adaptation of the pose and shape of the 3D model enables the transfer of the wound surfaces with minimal effort and high accuracy.

Exact transfer of the wound surfaces

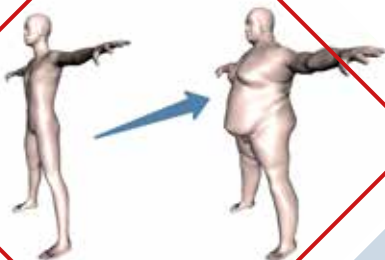
Surface 3D includes simple methods for transferring the wound to the virtual patient avatar. These methods make it possible to accurately draw burns on even the smallest regions. Thus, any change over time can be displayed accurately and clearly.

Extensive documentation

Surface 3D offers the possibility to store information about wounds and dressings as well as clinical findings, documents or photos directly on the corresponding body or wound positions of the 3D patient model simply by dragging and dropping. In this way, information about wound infections or complications, for example, can be documented consistently. This comprehensive documentation ensures a high degree of traceability of wound healing over time.

Surface 3D is a web-based application using modern web technologies such as Angular and three.js, ensuring platform-independent use. The software runs on Android, iOS, Windows, Linux macOS and directly in a web browser without the need for installation. It offers different user interfaces depending on the use case and can be easily adapted for other applications due to its modular design.

Platform independence



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BurnCase 3D

Objective diagnosis, documentation and evaluation of success

One research focus of the Medical Informatics Research Unit is medical modeling and simulation, which includes in particular research in the field of objective diagnosis and documentation based on virtual patients (three-dimensional models adapted to real patients).

Diagnosis and documentation of Severe burn injuries

The research work in this field was initiated by the Burn-Case 3D project, which is helping to optimize the scientific diagnosis and documentation of severe burn injuries. The determination of the extent of a burn injury by the treating physicians is often subject to large estimation errors and individual fluctuations. The computer-aided, complete and objective diagnosis and course documentation of the entire burn treatment creates a basis for evidence-based scientific evaluations. Through the automatic generation of evaluations and coding suggestions, BurnCase 3D combines a considerable increase in quality with a significant reduction in medical diagnosis and documentation effort.

Scientifically evaluable data

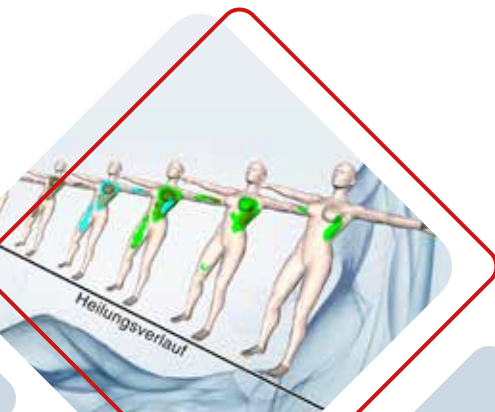
BurnCase 3D can be used independently of country and institution to support and optimize the diagnosis and documentation of burn injuries. By establishing this software in burn medicine, a large amount of scientifically analyzable data can be created, which is an important basis for studies and for the creation of a worldwide expert system for burn treatment.

Progress documentation for the evaluation of success

The results achieved in this field of application have shown the advantages of efficient and objective documentation on virtual patients. In the meantime, these findings and methods are being used, among other things, for chronic wound treatment. Especially here, an evaluation of the success of current therapies is only possible on the basis of chronological, structured and objective progress documentation. Especially in this medical environment, there is a demand for comprehensive qualitative data collection for

studies and thus for the creation of a scientific basis for a medical expert or decision support system. The research projects Qutis 3D and Surface 3D (web-based) should make this possible.

Special thanks go to senior physician Dr. Herbert Haller. He came up with the project idea and without his persistent and great support from the medical side, such a research project would not be feasible. Furthermore, we would like to thank all partners who were involved in the development of the software.



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VizARd

Augmented reality to support preoperative planning

Before certain operations, three-dimensional sectional images such as computer tomography (CT) or magnetic resonance imaging (MRI) are taken in order to plan the medical intervention precisely. In the future, surgeons will be supported by an augmented reality solution developed in the VizARd project. This software makes it possible to visualize this image data intuitively and in a user-friendly way directly on the patient's skin at the site of the incision.

Soft tissue and position recognition as challenges

Although there is a lot of valid data on humans and their "inner life," humans are anything but rigid "objects" because the position of the skin surface, soft tissue and organs changes depending on the position of the body. The research work is based on methods from the fields of augmented reality (AR) and deep learning, which have so far been developed specifically for the field of assistance systems. What has so far served to digitize humans, their tools and workpieces in the assembly hall is now being transferred to humans in the operating room.

Another key challenge is the deformation of soft tissue, which must be taken into account when visualizing image data. RISC Software GmbH's Medical Informatics Research Unit has already gained valuable experience in biomechanical modeling through previous projects. The visualization of medical images directly on 3D patients - instead of on a 2D screen - forms the basis for trend-setting research projects and for the improvement of existing applications in the medical field.

Unique support in preoperative planning

Based on AR technology, VizARd bridges the gap between the output of a digital workflow and a real object by combining static and mobile AR devices in a unique way. In doing so, the environment is perceived by 3D sensors in real time. Novel, non-rigid registration methods allow for high-precision mapping on deformable surfaces in this context. The exact positioning of devices or objects enables high-quality AR presentations. Overall, VizARd technology facilitates preoperative marking based on data from CT/MRI devices in hospitals.

Collaboration with MedUni Graz

The medical project partners from the Department of Plastic, Aesthetic and Reconstructive Surgery and the Department of Radiology at MedUni Graz contributed their expertise, in particular by assisting with the practical implementation and providing the medical application scenarios.

User-friendliness as an important goal

In order to ensure a high level of acceptance of the Viz-ARd technology among users, surgeons were involved in the development right from the start. The digital agency Netural GmbH was primarily responsible for designing the user interface of the software. The company has been conducting intensive research in the fields of e-health and medical technology for years.



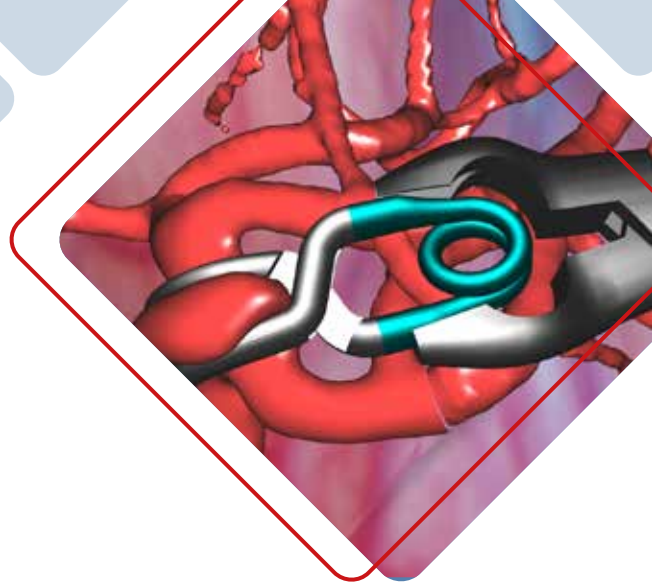
Netural

PROFACTOR

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Virtual Aneurysm

Haptic simulation of neurosurgical interventions

Disorders of blood circulation in the brain (stroke and cerebral hemorrhage) are among the leading causes of death in Western industrialized countries. Intracranial aneurysms, one of the main causes of bleeding, can basically be treated with two different strategies: The minimally invasive, endovascular method (coiling) uses a catheter to fill the aneurysm with a coil of wire, while the neurosurgical method (clipping) involves opening the skull and placing one or more titanium clips on the artery to cut off the aneurysm from the bloodstream.

Simulator for training clipping operations

As the endovascular procedure becomes more common for simple aneurysms, clipping is only used for complex aneurysms. Thus, it is becoming increasingly difficult for trainee neurosurgeons to find simple situations on which they can develop the necessary expertise for complex cases. The VIRTUAL ANEURYSM surgical simulator from the Medical Informatics Research Unit is designed to remedy this situation. It enables the training of clipping interventions in various virtual scenarios. The system is equipped with two

haptic input devices with force feedback and a stereoscopic display. Several aneurysm geometries with varying degrees of difficulty are available for selection, and users can choose from a list of more than 50 3D-modeled clips of different sizes and shapes.

At the beginning of the training, users practice proper head positioning and optimal positioning of the craniotomy for each case. During the actual clipping operation, the simulator continuously detects collisions between instruments and tissue and reacts accordingly. The realistic deformation of the blood vessels is calculated and visualized in real time using a specially optimized finite element method on the GPU (Graphics Processing Unit). The resulting forces are sent to the haptic devices so that the exerciser can feel the resistance of the tissue. Mounted on one of the devices is a clipping forceps with a sensor to measure the opening angle, which is transmitted in real time to the simulator. Depending on the selected level of difficulty, a rupture can also occur and the surgeons must stop the bleeding and treat the ruptured aneurysm within a specified period of time.

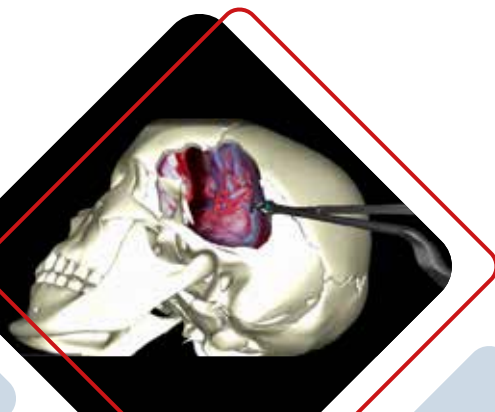


Objective training assessment

At the end of the training, users can view their result from all angles. To achieve an objective evaluation of the training, the blood flow through the artery with clamped aneurysm is calculated. This allows, among other things, an estimation of the induced stenosis as well as the residual flow into the aneurysm, which is incorporated into a final evaluation scheme. All training data is stored per user and can be visualized and compared at any time.

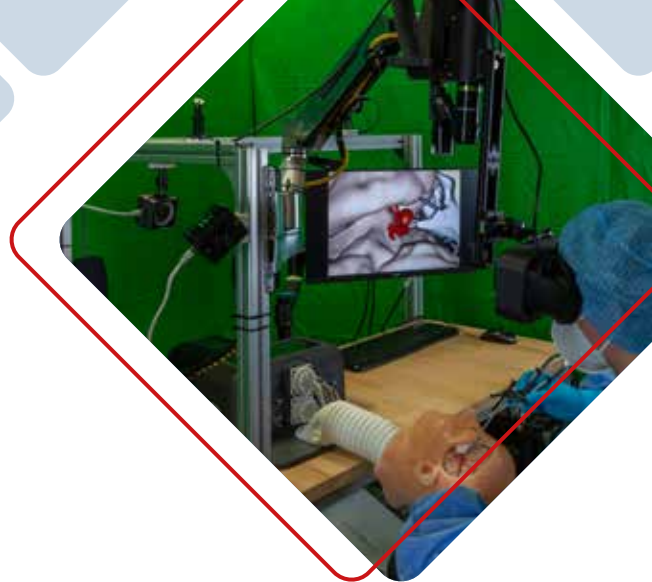
Project partners

This project was funded by the State of Upper Austria and the FFG as part of the BRIDGE program. Partners were the Kepler University Hospital Linz, Neuromed Campus, the General Hospital Linz and the German medical technology manufacturer Aesculap AG, world market leader for hand-held surgical instruments. The research results form the basis for the MEDUSA research project currently underway (see page 90).



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MEDUSA

“Medical Technology Lead Project” of the State of Upper Austria

The project “Medical EDUcation in Surgical Aneurysm clipping” (MEDUSA) has emerged from four submissions to the “Medical Technology Lead Project” tendered by the state of Upper Austria. The Medical Informatics Research Unit of RISC Software GmbH is the consortium leader of the lead project, which is endowed with 2.3 million euros. The aim of the MEDUSA consortium is to develop a revolutionary training and planning platform for neurosurgeons in order to simulate complex brain interventions in a detailed and holistic manner. The top priority of MEDUSA is to protect the lives of patients. Simulating complex medical procedures qualitatively and quantitatively in a realistic environment creates optimal training and education opportunities that increase patient safety.

Hybrid simulator for neurosurgeons

The brain is the most complex human organ, and damage to it due to disease has serious consequences for patients. However, surgical treatment of brain hemorrhages, for example, is extremely difficult because target areas are often embedded in highly functional and multilayered tissue

structures. Only high technology and exceptional cognitive and motor skills of neurosurgeons make successful interventions possible. Strengthening both components is the focus of the MEDUSA research project.

Neurosurgical interventions are complex and require the combinatorial application of several technical skills. Correct handling of instruments, use of imaging techniques and sensitive haptic sensations are essential. These versatile requirements are not met by current simulators. Based on a hybrid approach, the MEDUSA consortium is developing an innovative neurosurgical simulator consisting of an artificially manufactured skull including artificial brain tissue on the one hand, and virtually superimposed images, on the other hand, which extend the simulation environment in real time. Surgeons can thus haptically feel artificially manufactured patients and see internal, otherwise invisible anatomical structures in the form of virtually generated holograms. The real and virtual worlds merge to create versatile and realistic training opportunities for neurosurgeons.

Further leverage

In order to strengthen the scientific exchange within the consortium, a regular Journal Club was established under the direction of OA Dr. Matthias Gmeiner (Kepler University Hospital, Neuromed Campus). This Journal Club was offered for the third time in the winter semester 2021/22 as a course entitled "Literature Clubs, Project Presentations and Guest Lectures - Modern Concepts in Neurosurgical Surgical Planning and Training: Technical Innovations and Clinical Applications" at the Johannes Kepler University Linz also for medical students.

In the medium term, MEDUSA should lead to the establishment of a simulation and cooperation center in Upper Austria. Core technologies will be transferred into future medical products, such as surgical planning and navigation systems, which multiplicatively expand the achievable market, whereby the planned results have a far-reaching leverage effect.

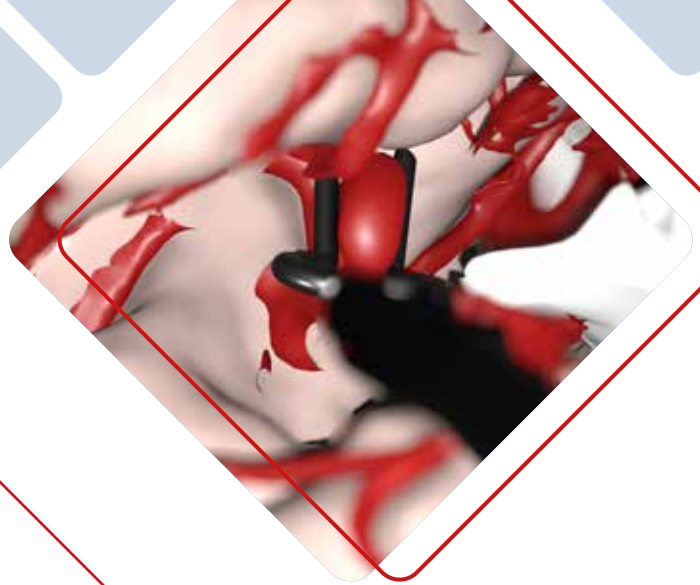
Bundling of core competences

This challenging project is possible due to modern technologies and especially due to the excellent expertise of the consortium, consisting →

"It is great that we have this flagship project in Upper Austria. MEDUSA catapults us right to the front in research and development."

Univ.-Prof. Dr. Andreas Gruber,
Head of the Department of Neurosurgery,
Kepler University Hospital Linz





→ of seven research and six corporate partners. The use of synergies in the fields of neurosurgery, neuroscience, artificial intelligence, medical technology, material sciences and medical products approval creates a lighthouse project that makes the business location of Upper Austria globally visible and establishes it in promising and profitable markets.



Photo from left: Dr. Michael Giretzlehner, Head of Medical Informatics Research Unit, RISC Software GmbH, Provincial Health Councillor Mag.a Christine Haberlander, Provincial Economic and Research Councillor Markus Achleitner and Prof. Dr. Andreas Gruber, Director of the Department of Neurosurgery, Kepler University Hospital Linz.

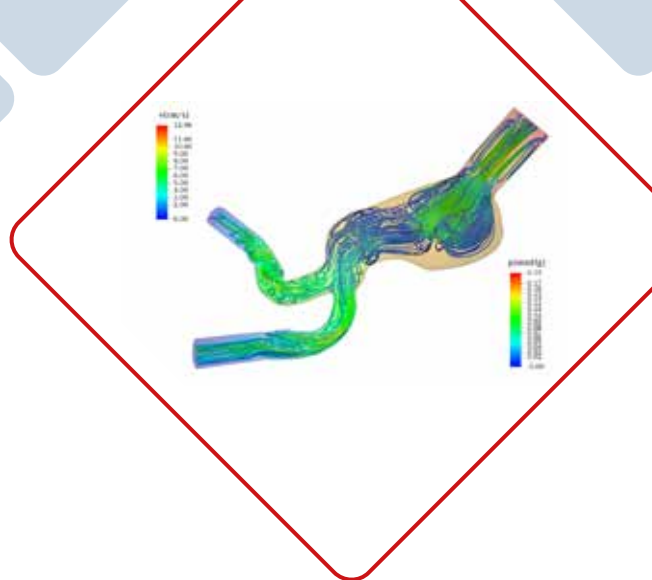
Source: State of Upper Austria/Lisa Schaffner



Medusa

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EndoPredictor

Artificial intelligence to predict complications in aortic aneurysm treatments

Aortic aneurysms, dangerous bulges of the aorta, are among the most common vascular diseases and cause thousands of deaths each year in Europe and the USA alone. While open surgery involves greater stress during the operation as well as a longer recovery time, the so-called endovascular treatment is fraught with a number of complications after the operation. In endovascular treatment, a stent-graft - a type of tube - is inserted through the blood vessel and placed directly at the aneurysm. This is to prevent the aneurysm from rupturing by relieving pressure on the vessel at that point and allowing blood to flow through the stent-graft.

EndoPredictor

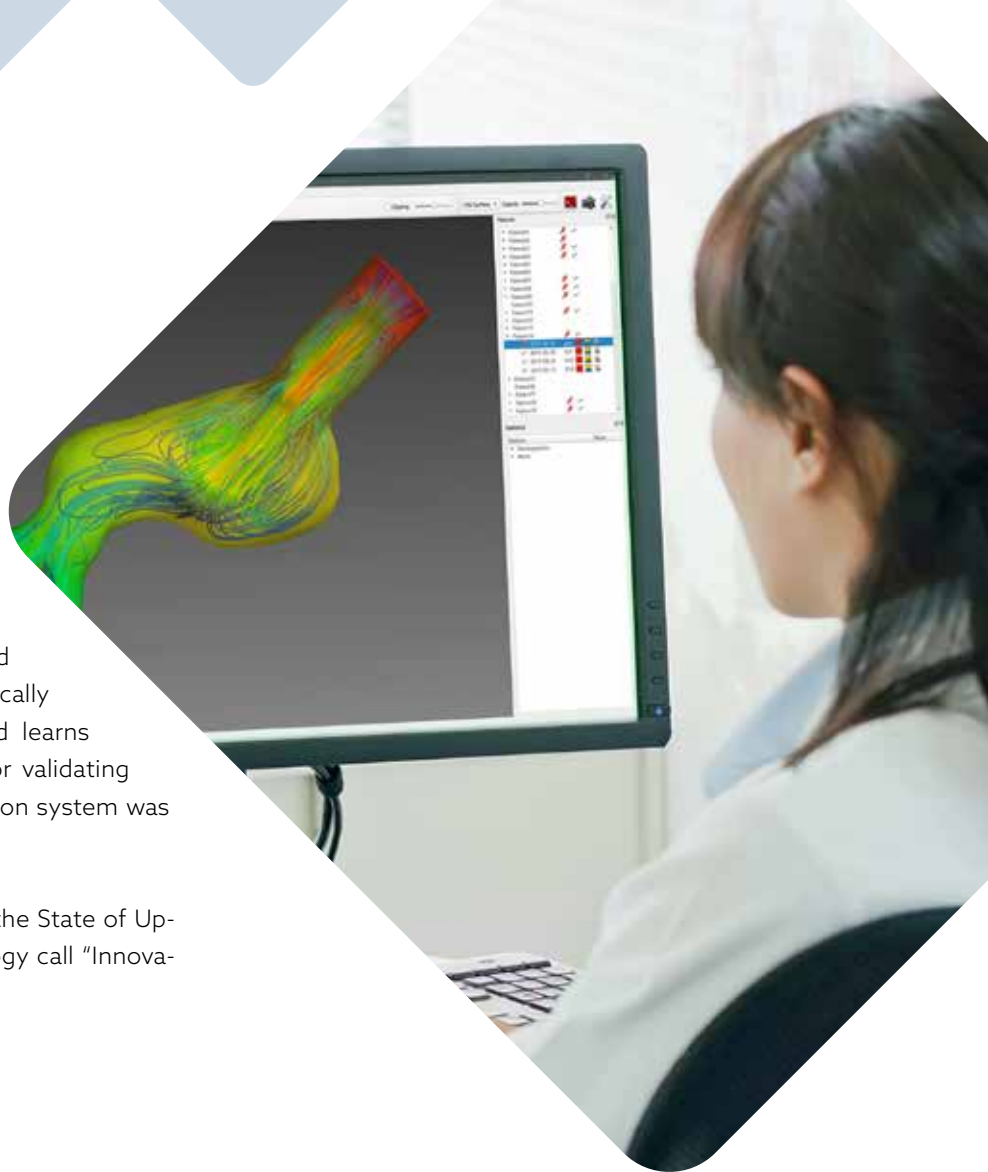
In the EndoPredictor project, researchers from the Medical Informatics Research Unit, together with physicians from Kepler University Hospital Linz and MATTES Medical Imaging GmbH, developed methods to extract and digitally map characteristics of the abdominal aorta and aneurysm from medical image data. For this purpose, 50 anonymized

patients datasets consisting of computed tomography angiography (CT-A) images before the procedure and from several follow-up examinations after the endovascular treatment were used. From these image data, the aortas and stent-grafts were modeled, blood flow through the stent-graft was simulated, and a possible change in stent-graft position and shape at follow-up was calculated.

Automated prediction of complications

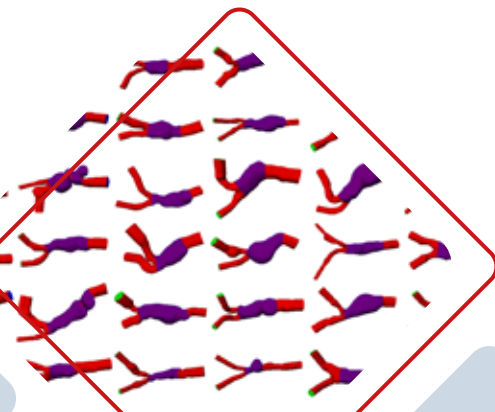
A total of 201 CT-A image datasets were examined and 42 measures were calculated for each. These measures describe the shape of the aorta and stent-graft as well as properties obtained from simulated blood flow. We examined which measures showed statistical correlations with complications such as leaks, vasoconstriction or vessel occlusion. The prediction of these complications was performed using a specially developed method. The result is a software system for the automated prediction of postoperative complications after endovascular treatments. A prediction accuracy of up to 88 % could be achieved.





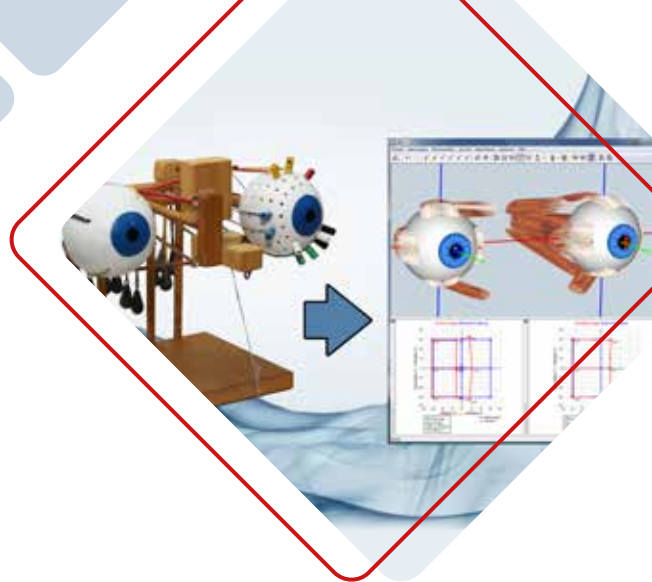
The developed prediction method is based on machine learning techniques, automatically detects relevant features in the data and learns from previous datasets. A new method for validating feature selection while training the prediction system was implemented.

The EndoPredictor project was funded by the State of Upper Austria as part of the medical technology call "Innovative Upper Austria 2020."



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SEE-KID / CEVD

Biomechanical simulation of ocular malpositions and strabismus surgery

The research initiative SEE-KID / CEVD has been dealing with the computer-aided simulation of ocular malpositions and their surgical correction for more than 20 years. A major milestone was the development of the software system SEE++ as a novel teaching and learning tool, which supports vivid thinking especially in complex functional disorders. In addition to a biomechanical model of the human eye, the software system offers a three-dimensional virtual simulation of the patients eye in combination with a realistic representation of muscle shape and movement. This enables an interactive simulation of malpositions and eye muscle operations.

Continuous further development of the software

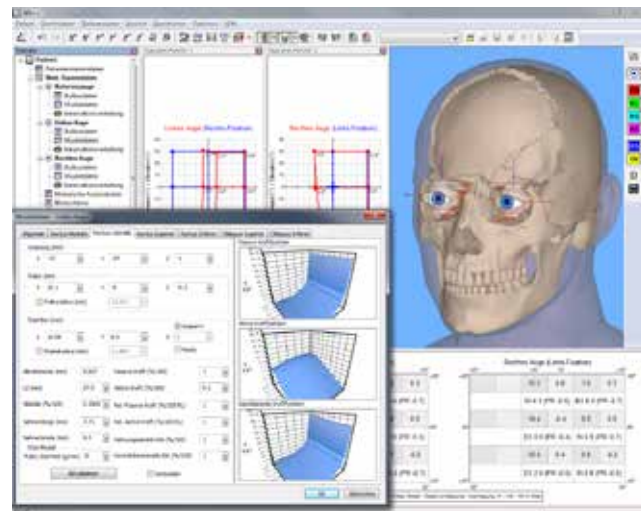
In order to improve the use of the software in teaching and training, the 3D representation of the virtual patients has been continuously developed over the development period. Thus, the software now also includes the integration of the brain as well as a dynamic representation of individual parts of it. The numerous interaction options for the

individual brain parts as well as the possibility of drawing in various classifications on the brain surface and displaying medical information about them contribute significantly to a better understanding of the connections between the eye and the brain.

Amblyopia diagnosis and therapy with AmblyoCare

Another flagship of the research project is "AmblyoCare." This application offers standardized and variable tests for the classic amblyopia treatment methods on the computer in order to better record additional characteristics of the visual process and thus make visual tests more useful for everyday life. The flexibility of the software makes daily work with patients much easier. The practical application of AmblyoCare in the clinic takes place in amblyopia diagnosis and therapy, as well as in early vision support, where AmblyoCare increasingly supplements or even replaces conventional aids, such as the Nystmus drum or picture cards.

RISC Software GmbH would like to thank Prof. Dr. Priglinger in particular for his tireless commitment to the SEE-KID / CEVD project. We would also like to thank Mag. Ausweger from the Barmherzige Brüder Hospital in Linz and Prim. Univ.-Prof. Dr. Priglinger jun., Prim. Univ.-Prof. Dr. Fellner and Dr. Brock from Kepler University Hospital, Med Campus III, for their sustained support. Many thanks also to Prim. Priv. Doz. Dr. Hörantner from the Hospital of the Sisters of Mercy Ried as well as FH-Prof.in Scharinger, MBA from the University of Applied Sciences Salzburg and Mrs. Hirmann, MBA from the FH Campus Vienna for their good cooperation.



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MC³ – Medical Cognitive Computing Center

The future of modern medicine in Linz

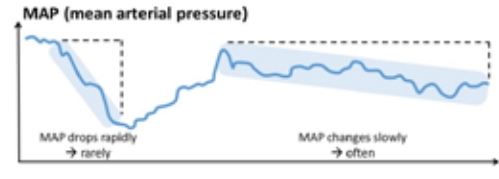
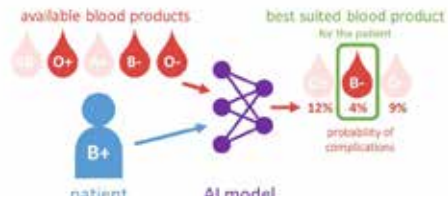
The State of Upper Austria sees artificial intelligence (AI) as one of the most important technology trends of the next decade and is therefore creating the new Medical Cognitive Computing Center (MC³), a center to research and implement optimal patient care through the use of novel methods in the field of artificial intelligence. The MC³ combines the knowledge, expertise and experience of the partners Johannes Kepler University Linz (JKU), Kepler University Hospital Linz (KUK) and the Medical Informatics Research Unit of RISC Software GmbH.

Univ.-Prof. Dr. Jens Meier, head of the University Department of Anesthesiology and Operative Intensive Care Medicine and head of the Department of Neuroanesthesiology and Intensive Care Medicine at Kepler University Hospital, is one of the few physicians with experience in basic medical research related to artificial intelligence to systematically improve patient care. "One advantage of using AI methods in medicine is the recognition of previously unnoticed correlations," says Univ.-Prof. Dr. Jens Meier.

At JKU, there are several very successful research groups in the field of artificial intelligence, most notably the Institute for Machine Learning, headed by Univ.-Prof. Dr. Sepp Hochreiter. In a unique way, scientific expertise and experience in machine learning are combined with the application areas of biology, genetics and medicine.

The Medical Informatics Research Unit of RISC Software GmbH has a strong position in the field of medical informatics due to its approximately 20 years of collaboration with physicians and healthcare providers and contributes its know-how and experience to the MC³ project, especially in the area of AI-based medical data analysis and prediction.

Within the framework of the MC³ project, a center is being created that combines the fields of medical research and AI research into a combined focus for the healthcare system in Upper Austria. This will result in knowledge- and data-intensive methods for the further optimization of clinical patient care with a scientific focus on health care research and patient safety.



In MC³ solutions are being worked on for the following medical problems:

- Transfer management: Can a patient be safely transferred from the ICU to the normal ward?
- Manchester Triage: What is the treatment priority of a patient coming to the emergency department?
- Blood transfusions: Are side effects or adverse events expected with a blood transfusion?
- Deterioration of condition: Will the condition of an ICU patient deteriorate in the near future?
- COVID-19: Can the progression of COVID-19 disease and the likelihood of COVID-19 death be predicted from blood values?

The project partners in MC³ are specialists when it comes to the use of AI in medicine. They have access to know-how and databases that are usually not available to other IT companies. Kepler University Hospital has been collecting all clinical data in a well-maintained data warehouse for more than ten years. This data can be exported anonymously and used in accordance with legal regulations. The rights of patients are safeguarded by the involvement of the ethics committee and by compliance with all regula-

tions, first and foremost the DSGVO and the Medical Devices Act. Since only retrospective data is analyzed, there is no risk to patients. Due to the close cooperation between physicians, bio- or medical computer scientists and AI experts, a professional understanding of the problems is available. This guarantees both medically and methodologically correct processing of data and predictive models.

MC³ enables the preservation and expansion of highly qualified jobs. Furthermore, a very high quality education within a scientifically excellent and interdisciplinary environment is made possible. The development of scientific experts in this field should enable the growth of the center itself, on the one hand, and increase the visibility and attractiveness for international scientists, on the other hand. MC³ also contributes significantly to the competitiveness of Upper Austria as an economic location.



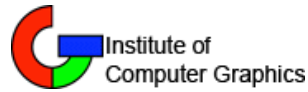
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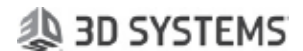
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