

**Why do algorithms
improve our quality
of life?**

**Industry focused,
creative, passionate and reflective;
we think beyond institutional
boundaries.**

Analysis, Modelling,

Simulation, Optimisation

Challenge

Data analysis, modelling, simulation and optimisation are the main areas of work at the Institute of Applied Simulation (IAS).

The problems of our society are becoming ever more complex and require dynamic methods of investigation, a good understanding of systems and new approaches to problem solving. These need to be based on accurate predictions and precise planning, taking both spatial and temporal dimensions into account.

We use various modelling techniques to detect and describe interrelationships in systems.

In addition, we apply various simulation techniques to make complex dependencies and temporal progressions visible and understandable. Modelling and simulation furnish the basis for further analysis and optimisation.

Modelling and simulation are essential in our work to transfer knowledge from theory into practice and to develop intelligent and sustainable solutions. We use methods and algorithms from basic research to develop new solutions to current problems, which we implement using modern techniques and tools.

Systems Engineering

Our expertise in modelling, simulation and optimisation, applied to challenges in the life sciences and facility management, is unique in the Swiss higher education landscape.

We develop comprehensive solutions involving systems analysis, conceptualisation, implementation, commissioning and the maintenance of models and simulations.

We implement time-critical services and consulting assignments using the methodical procedures of systems engineering.

Tools

The central tools we use in the development of our solutions are a variety of simulators, statistical packages, programming languages, web technologies, development environments for smart phones and in-house developments in the field of system optimisation and data mining.

Approach

Conventional planning tools are no longer sufficient for solving complex problems. By visualising system structure and behaviour in a model and checking them in space and time in the simulator, we reduce complexity and thus achieve new insights.

Our expertise and the techniques we apply enables us to make rapid and high-level scientific progress in areas where Computational Science converges with Life Sciences and Facility Management.

 We develop smart, sustainable and practical solutions using various simulation and modelling technologies and the very latest tools.

The Potential of

Computational methods...

Computational Life Sciences

With the advent of new technologies, the Life Sciences are developing rapidly and producing vast amounts of data. Computational methods are assuming a fundamental role in addressing the challenges of analysing data, extracting useful information, making it available in databases, and modelling and understanding underlying complex systems.

New data and knowledge have the potential to transform the industry. Indeed, today a variety of fields, such as, pharmaceuticals, biotechnology, ecology and agriculture, are already taking advantage of the era of big data.

In the biomedical, pharmaceutical and other life sciences industries, there is a growing need for experts who understand the specifics of data management, modelling and computation in the context of a life sciences discipline and the corresponding business environment.

The IAS Institut of Applied Simulation is responsible for the Masterprogramme Applied Computational Life Science. This specialisation provides the students with the opportunity to enter a research oriented, industrially and socially relevant domain. The programme equips the candidates with essential expertise in a field where science meets business and opens up career paths in international companies, agile start-ups as well as research institutions.

We are developing new education programmes for computational life sciences.

Team

Our team consists of 40 people, mainly physicists, mathematicians, engineers and computer scientists.

Our research teams work on the following topics:

- Applied computational genomics
- Biomedical simulations
- Predictive analysis and forecasting
- Self-learning systems and bio-inspired algorithms
- Process simulation and process optimization
- Data modelling and information exchange technologies

We have extensive experience in the management of interdisciplinary projects with other organizations in the ZHAW, other universities of applied sciences, national and international universities.

We see ourselves as intermediaries between the basic research carried out at universities and its workable application in business and society.

We are the intermediaries between university-level basic research and its practicable application in the world of work and society as a whole.



Fields of research

Personalized Health

- People are living longer
- People want to enjoy life fully until an advanced age

In the field of complex biomedical systems, the IAS is working on options for the early detection of aneurysms. As one of the leading institutes at universities of applied sciences currently working in the fields of applied bioinformatics and computational genomics, the IAS carries out research into molecular structures and interactions for use in medical applications.

Energy

- Energy demand is continuously increasing; fossil fuels are finite
- The share of renewables in total energy consumption needs to be increased
- More powerful technologies are helping to conserve natural resources

In the area of short- and medium-term forecasts on energy production from alternative sources, energy consumption and energy distribution, the IAS uses modelling and simulation to help implement the «energy turnaround».

Industry

- Demand is rising, while global industrial production is steadily increasing
- More and more people want access to better products

Logistical costs currently account for between 5% and 15% of companies' total sales. The IAS has more than 20 years experience in the implementation of sustainable and lean logistics solutions, using logistics simulation and optimisation algorithms.

Demographic Change

- The population is growing
- The average age of the population is increasing

The IAS is carrying out groundbreaking research into issues facing the agricultural, food and health care industries. The development of intelligent control for urban farming and of expert and forecasting systems in hospitals is also part of the IAS's work, as is bioinformatics, which contributes to medicine and to agriculture at molecular level.

Urbanisation

- For the first time in history, more people are living in cities than in the countryside
- Urban agglomerations are growing

In Switzerland, two thirds of the population are already living in cities. The associated infrastructural demands are opening up enormous potential for businesses. To ensure continuous economic development and to increase competitiveness, it is vital to develop the infrastructure of urban areas. For this purpose, knowledge management is becoming a central task for sustainable development in fields such as efficient energy and telecommunications networks, roads, water supply and disposal systems. The IAS develops solutions which map expert knowledge in the form of rules that allow communication with smart information systems.

Mobility

- Distances travelled are constantly increasing
- Distances need to be «shortened» through intelligent solutions

In the framework of national research projects, the IAS has made contributions to congestion reduction and forecasting, as well as tour and transport planning. This also includes questions of site selection and the distribution of goods.

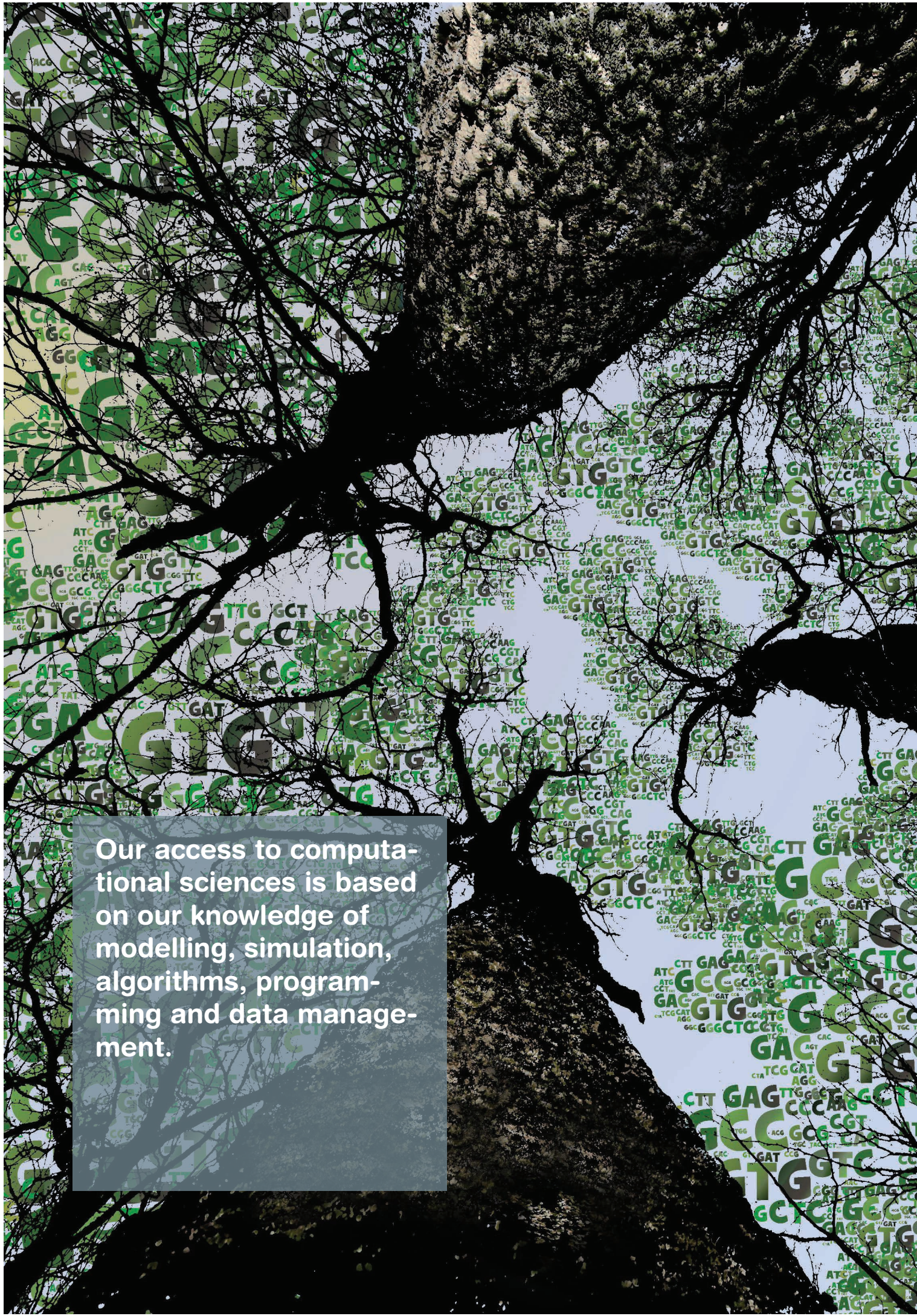
Big Data & Knowledge

- Companies have to deal with increasingly large amounts of data > Volume
- Different data structures or unstructured data > Variety
- Constantly increasing speeds are required for the transmission and analysis of data > Velocity

Knowledge is rapidly becoming the strategic success factor for companies, while the transformation of data into productive knowledge remains a major challenge. Internationally recognised specialists at the IAS assist clients in selecting, processing and evaluating their company's data and its integration into external data clusters, with the aim of generating knowledge.

We are working on the challenges of
Volume – Variety – Velocity

Our fields of research cover important developments in technology and society.



Research groups

Applied Computational Genomics

We focus on theoretical and computational aspects of modelling genome evolution and adaptive change. We provide accurate and scalable computational solutions for large and complex molecular data, so that a wide range of scientists can analyse patterns of evolution and natural selection in genomic and omics data.

Our methods allow inferences of evolutionary history and selection from molecular data, helping to generate new biological hypotheses and predictions for further experimental validation. Practical applications of phylogenetic methods range from biotechnology and biomedical research to ecology, forensics and agriculture.

Areas of application

- Stochastic models of biological processes
- Fast multiple sequence alignment and phylogeny inference methods
- Model-based analyses of function conservation, or adaptation to pathogens and new environments
- Analyses of protein-coding genes and codon biases
- Statistical methods for analysing tandem repeats in genomic sequences
- Data integration and semantic web in bioinformatics and beyond

Computational Genomics: algorithm and computation for genomics data

Predictive & Bio-Inspired Modelling

The research group is concerned with the design and development of adaptive systems for industrial and business applications, based on the expertise on machine learning as well as different simulation methods. A central speciality of the group is the development and research on complex (i.e. multi-methodical) forecasting systems with an application focus on areas of life sciences and facility management, and their interfaces.

Frequently nature impresses us with examples of how systems learn to regulate themselves in future-oriented ways, and to optimise processes. Learning in systems, often in bio-inspired ways, is another focus of the research group.

Areas of application

- Forecasting and expert systems with an application focus on life sciences and facility management
- Self-learning systems for object and pattern recognition or process control
- Statistics, data analysis and experimental design for scientific and industrial applications

Bio-inspired Modelling and Learning

Systems: detecting, understanding and learning for the future

Simulation & Optimisation

The research group has a proven track record in implementing sophisticated simulation and optimisation projects. More than 300 such projects have been implemented in the last 25 years.

The procedural concept developed at the Institute, together with its user-friendly simulation interface, provide an important basis for the holistic observation and testing of various solution options, and for their optimisation.

Flows of materials, people, traffic and information are simulated and optimized.

Areas of application

- Visualising processes and identifying dependencies, determining and assessing critical factors
- Creating transparency and understanding through dynamic observation in the simulation model
- Optimising processes and saving resources
- Dynamic planning for companies and buildings
- People flow and transport simulations
- Site selection and evaluation of variants, taking different production scenarios and market developments into account

Simulation: capacities and costs and their dynamic dependencies over time

Our access to computational sciences is based on our knowledge of modelling, simulation, algorithms, programming and data management.

Research groups

Biomedical Simulation

It is truly ambitious to model natural processes. Nature is unique and overwhelmingly complex – modelling in turn is per definition reductionist. Systems biology combines biological insight with mathematical simulations to reproduce the behavior of biological systems.

We interpret medical images and fuse clinical data with machine learning approaches. We then incorporate biological processes involving continuum techniques (FEM, FD) and own custom code. To verify the findings we develop effective parameter fitting and validation strategies.

Areas of application

- Machine learning and image analysis fuse knowledge with medical data
- Simulation of heat propagation in various foods determines food safety constraints
- We develop new simulation approaches to predict endothelial cell function, blood coagulation and the remodelling of tissue
- With system dynamics we build robust models, e.g. to optimize chemical reactors
- Computational fluid dynamics simulates blood flow with stents
- Visualization tools facilitate the interpretation of clinical data

Biomedical Simulation: fusing clinical data and modelling physiology to build diagnostic tools

Knowledge Engineering

Information and the knowledge derived from it have become two of the most important production factors in our economy. The research group breaks down information and expert knowledge into their basic building blocks so that they can be integrated into a variety of computer applications.

Expert systems and self-learning, bio-inspired algorithms are used, inter alia, to make information quickly accessible and solution-oriented.

The technologies used range from smartphone apps to complex integrated online systems.

Areas of application

- Collecting and analysing information, data and processes in interdisciplinary projects
- Processing, structuring and integrating large data and knowledge bases
- Implementing self-learning, fault-tolerant algorithms
- Usability concepts and design
- Interactive communication and visualisation
- «Internet of Things» and Industrie 4.0 application

Knowledge Engineering: structuring and providing expert knowledge

Predictive Analytics

Everybody wants to know «what will happen next». We book holidays hoping for fine weather, invest in stocks hoping for good returns, drive another 100km without refueling expecting that what is left in the tank is still enough to reach the destination. We all engage in speculations and guessing future outcomes, and if we are smart enough, we use additional information to increase our chances of guessing right. And our brains evolved to be exceedingly good at it. But there are limits: we are 3-dimensional creatures, and reasoning in a space exceeding three dimensions is painstakingly hard.

Enter the computer. With the computing power harnessed in silicone, it is now possible to crunch through massive amounts of data, infer missing information, select and extract predictive features and build sophisticated models. It is possible to reason not only in three, but in hundreds and thousands of dimensions, and to discover connections and dependence between variables which could otherwise stay obscure.

Areas of application

- Predictive and prescriptive maintenance
- Prediction and diagnostics in medtech
- Dynamic behavioral analytics
- Multimodal information fusion for predictive analytics

Predictive Analytics: machine learning and data mining to make predictions about the future



Our expertise and technical approach result in a rapid and high-level scientific progress in areas where Computational Science converges with Life Sciences.

Cooperation

Partners

Clients and project partners of the IAS include companies and organisations from a wide range of industries and sectors, trade associations and public institutions.

Customers and partners benefit from over 20 years of domestic and international experience in interdisciplinary research projects.

Networks

The IAS is linked to all the renowned national universities via research cooperation. We maintain international research relations and have excellent connections with a broad network of institutions within the ZHAW. The Institute actively supports the exchange of knowledge and experience between various network organisations.

Forms of cooperation

Research projects

The IAS's research and development projects are supported by funding (CTI, SNF, EU). State funding institutions, international research programmes and foundations promote innovative, promising projects.

Service projects

Assignments from industry and public institutions are executed by IAS employees at market rates and with guaranteed deadlines.

Student work

Under the supervision of lecturers and academic staff, students work on projects from the field as part of their semester assignments and Bachelor's or Master's theses.

Contact

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We deliver smart sustainable solutions.

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The IAS Institute of Applied Simulation is part of the School of Life Sciences and Facility Management of the ZHAW Zurich University of Applied Sciences located in Wädenswil above Lake of Zurich.