DTU Compute

Department of Applied Mathematics and Computer Science
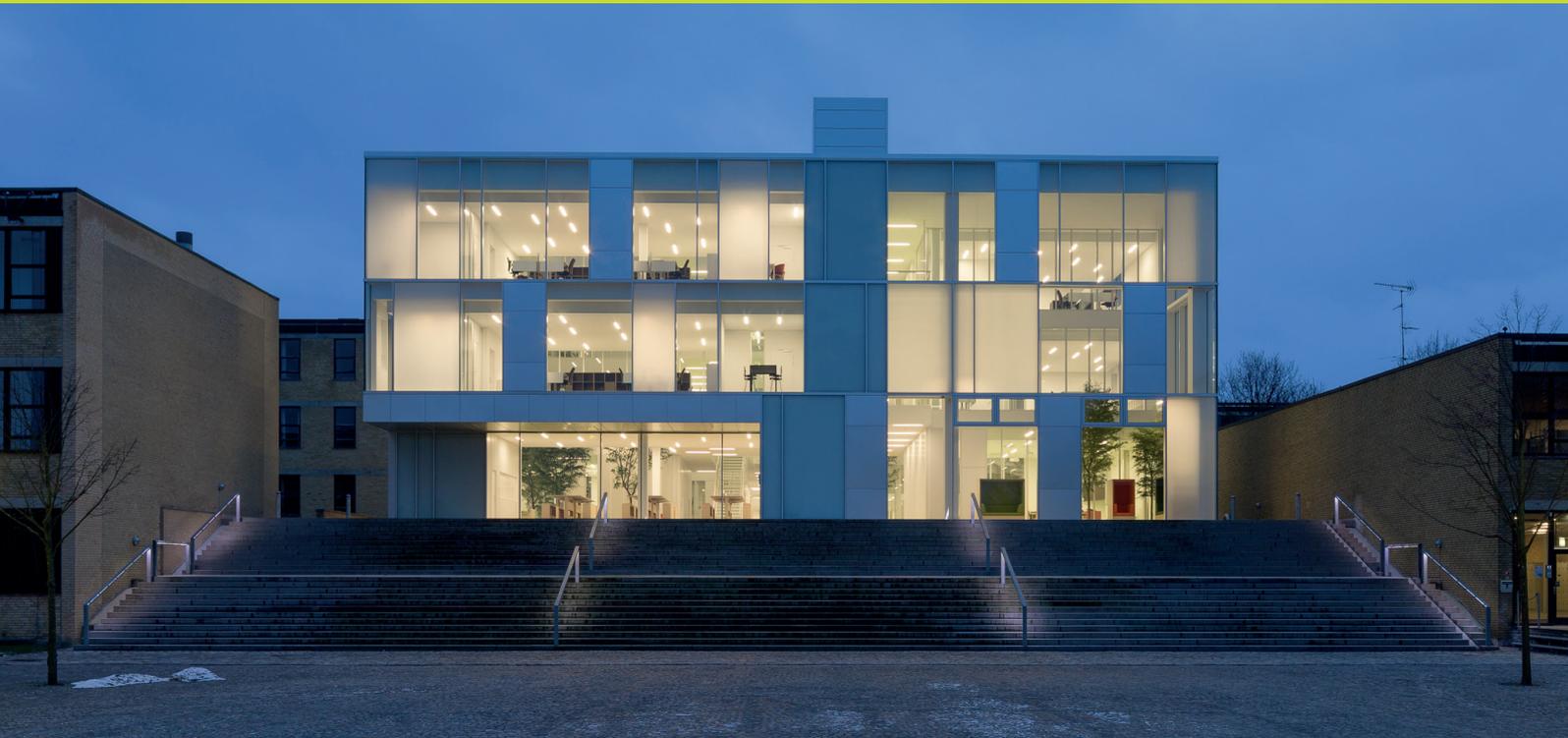
Welcome to DTU Compute

Denmark's largest environment for mathematics and computer science

Mathematics and computer science are in everything - from the artificial pancreas to the self-repairing computer through forecasts for surplus wind energy to Facebook and Google. IT and mathematics lay the foundations for what we can achieve, constituting the key technologies for future society.

Denmark - and, indeed, the rest of the world - is currently at the frontier between industrial and digital societies. DTU Compute is one of the players that is taking the lead. And we are not alone. We are making great strides in collaboration with the students and other DTU departments, the industry as a whole, public sector institutions, authorities and other universities in Denmark and abroad; in short, everyone keen to help create the new world.

All engineering students have to spend some time at our department as a part of their programme at DTU. At the same time, we educate many engineers who go on to become specialists in precisely our academic fields. Together with our students, we create knowledge and innovation to help develop tomorrow's society.

DTU Compute encompasses both in-depth theory and practical applications. This allows us to convert new ideas into innovative products and provide public sector consultancy - to the benefit of both the business community and public sector institutions.

We take on problems and challenges from other disciplines and position them in a virtual world where we can build models, perform calculations and run simulations. We can then relate the results from this work back to the real world and find solutions to a wide range of problems.

Hot topics today include 'big data' - processing huge data volumes - 3D printing, or tiny sensors placed on clothes or inserted under the skin to measure how we feel and what we need, better foods or bespoke pharmaceuticals. All areas where DTU Compute is in the thick of things.

This brochure provides a little peep into our world.

Professor Helle Rootzén, Head of Department at DTU Compute

DTU Compute's mission is to give innovation input a real boost. We will do so by partnering with a wide range of companies and public sector institutions

We create value in society

From research to value
- Large-scale commissioned research assignments
- Research and development projects
- Research commercialization

Competencies and new qualifications
- Bespoke education programmes, supplementary education
- Partnerships with students
- Researcher training programmes

Advice and service
- Research-based consultancy service
- Access to laboratories, research facilities and research centres
- Public sector consultancy

The new technologies of the future
- Strategic focus on companies' technology needs
- Access to leading research environments in the field of information and communication technology (ICT)
- Innovation network in the area of audio technology, for example
- Development workshops in partnership with companies

We are unique because our combination of research in applied mathematics and computer science sets the agenda for what we can achieve in the future.

Together with our students, we create knowledge and innovation to help develop the digital society of the future.

Education programmes

DTU Compute contributes content to the following programmes:

*Bachelor of Engineering: ***
BEng, Internet Technology and Economics
BEng, IT

Bachelor of Science:
BSc – Mathematics and Technology
BSc – Software Technology

Master of Science:
MSc, Computer Science and Engineering
MSc, Mathematical Modelling and Computation
MSc, Digital Media Engineering

PhD:
To find out more about our PhD programmes,
visit compute.dtu.dk

* A number of our BEng programmes will be renamed in 2013.

Research sections

Algorithms, Logic and Graphs	ALGOLOG
Image Analysis and Computer Graphics	IMAGE
Dynamical Systems	DYNSYS
Embedded Systems Engineering	ESE
Cognitive Systems	COGSYS
Cryptology	CRYPTO
Language-Based Technology	LBT
Mathematics	MAT
Scientific Computing	SC
Software Engineering	SE
Statistics and Data Analysis	STAT
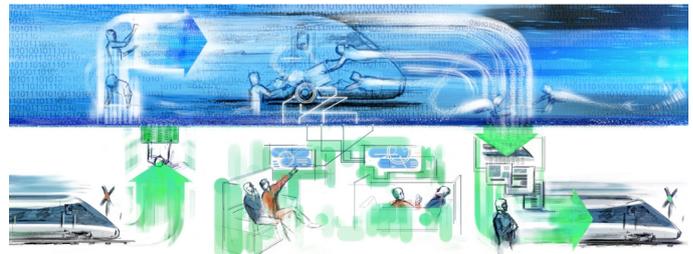
Twenty-four trees decorate the interior of the new building 324 on DTU Lyngby Campus, which DTU Compute moved into shortly after the merger between DTU Informatics and DTU Mathematics in 2013. Glass facades surround the 4,600 m^2 of space that the building comprises, and the interior walls of the offices and meeting rooms inside are likewise made of glass. This transparency helps daylight pass through the facade and penetrate deep into the building, also allowing us to maintain line of sight across offices.

DTU Compute staff can now use new, shared office space as the building 324 facilities make it possible for employees to work in groups of 6–12. Almost all offices are linked to a designated meeting room and/or project room.

The department is housed on the first and second floors of the building, above a thriving mass of students attending lessons in the modern teaching facilities on the ground floor. The rooms are bordered by furnished areas providing space for students and staff alike to work, chat or enjoy a short break.

However, as building 324 only has space for 120 staff, the department employees are also to be found in buildings 322, 321 and 303B on DTU Lyngby Campus.

DTU Compute has been laid out specifically to oblige staff and students to use different buildings. This ensures that we meet each other on a regular basis - sometimes in a random setting, as it is often the case that chance and informal encounters generate new ideas and promote thinking outside the box.

Online mathematics lessons

On the Mathematics 1 course, we leverage IT and the Internet to the full extent. Conventional text books and printed weekly lesson plans have given way to eNotes, video lessons and electronic assignments with links to theory resources, help and explanatory examples.

We still believe that physical lessons, lectures and group work have an important role to play in mathematics teaching. But we are also well aware that Mathematics 1 comprises 14 very different bachelor's directions, and that DTU students are keen to find the ways of working that suit them best. As a result, flexibility is the key. Students can attend lectures in the auditorium, watch them as live streams on the Internet, or catch them on YouTube at home while sipping a café latte, perhaps …

We can always work with mathematics - anywhere and anytime. The materials and help functions that make up the course are never more than a mouse click away.

Trail-blazing help for diabetics

In patients suffering from Type 1 diabetes, the pancreas has lost its ability to produce insulin.

This means that they must regularly inject themselves with insulin. What is more, they have to take care to adjust the volume of insulin they inject to match the amount of carbohydrates in their diet, their levels of physical activity and stress, their alcohol consumption and so on. This is very difficult to do, and the consequences of a diabetic person taking an inappropriate dose of insulin can be extremely serious.

A group of DTU Compute researchers have joined forces with Hvidovre Hospital and the company Medtronic to develop an artificial pancreas that continuously and automatically administers the correct volume of insulin. This reduces the risk of consequential illnesses from diabetes and allows people suffering from Type 1 diabetes to live an almost completely normal life.
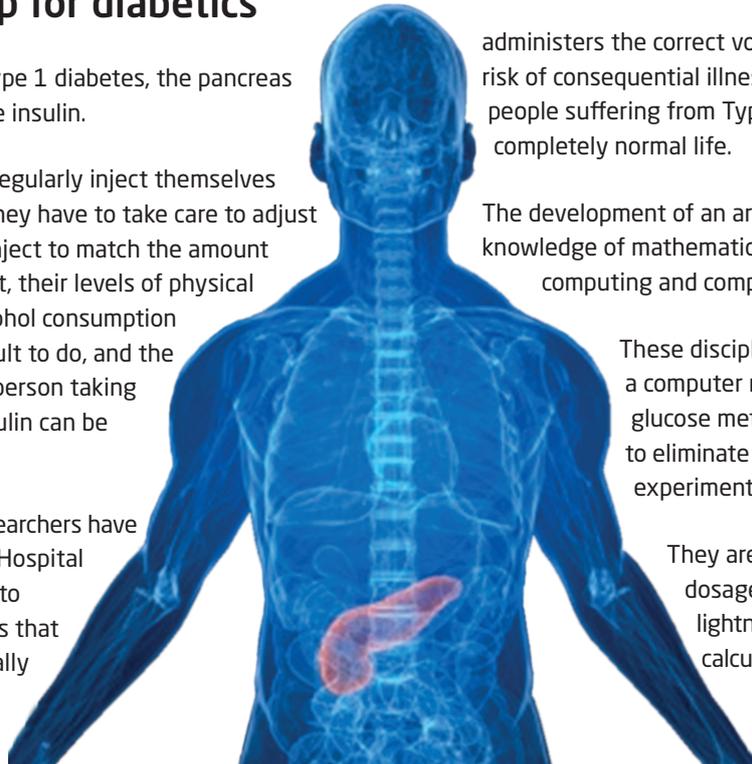
The development of an artificial pancreas demands in-depth knowledge of mathematical modelling, statistics, scientific computing and computer science.

These disciplines are used to develop a computer model that can simulate the glucose metabolism in the human body so as to eliminate the need for dangerous medical experiments.

They are also used to calculate the exact dosage of insulin, which is the result of lightning fast, complicated mathematical calculations performed on a smartphone.

Algorithms and advanced mathematics go hand in hand

At DTU Compute, we use advanced mathematics when designing and analysing algorithms (calculation models).

We use algorithms when we need to process huge volumes of data (big data) for effectively searching in video data, for example, or checking high school assignments for plagiarism.

At the same time, our various algorithmic assignments inspire us to solve the mathematical problems that arise during the process, or to tackle problems in the graph theory used for the algorithms.
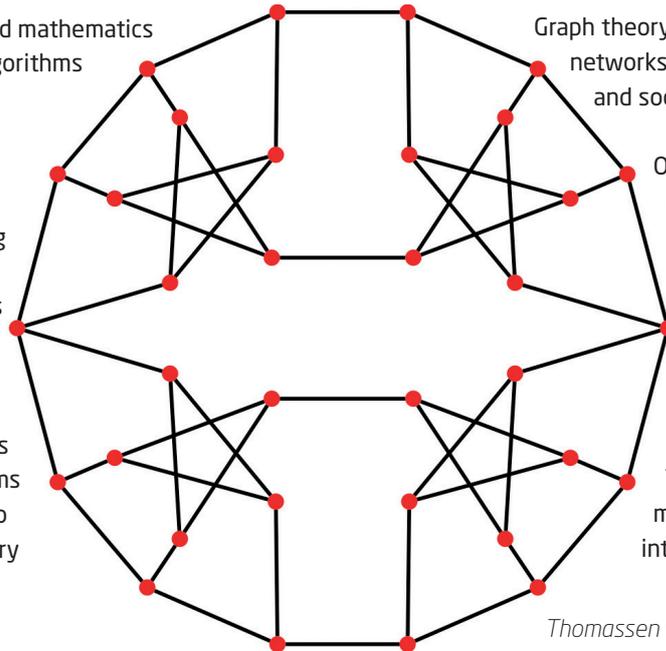
Graph theory is a mathematical abstraction of networks such as roads, railways, the Internet and social media.

One of the key and unsolved problems in graph theory is called the 'Tutte 3-flow conjecture'.

DTU Compute has recently contributed to solving this 25-year-old problem with a theory called the 'weak 3-flow conjecture'.

This is truly ground-breaking fundamental mathematical research at international level.

Thomassen Graph

The key to a fossil fuel-free future

Denmark's ambition is to lead the way in introducing fossil fuel-free energy, and the country has chosen to focus on wind energy to achieve this aim. The challenge here is that energy will only be available when the wind blows.

A group of DTU Compute researchers have therefore developed a number of models and tools to help forecast wind energy production.

These methods have become the global benchmark and are now used in tools such as WPPT (Wind Power Prediction Tool) from ENFOR a/s. WPPT is used today to predict wind energy production on a continuous basis throughout Australia, North America and Europe.

Tomorrow's energy system is fossil fuel-free, and new IT solutions developed by DTU Compute are playing a key role.

Invention attracting interest from NASA

The incredible capacity of the human body to 'repair itself' was the inspiration behind an invention, a patent and - now - the company Biomicore. A group of DTU Compute researchers set out to transfer the self-healing capacity of human cells to computer hardware.

The researchers developed a computer, which, instead of using a central CPU (a central processing unit that handles the computer's calculation function), utilises a network of very small CPUs or 'cells'. If a 'cell' ceases to function as it should or dies, another 'cell' simply takes over its role. In other words, the computer itself moves the functions away from damaged areas without any human involvement at all. This makes the computer so robust and reliable that NASA has shown interest in the invention and, in partnership with NASA, a prototype has already been tested in an instrument application. The invention of the self-repairing computer has been commercialised through the establishment of the company Biomicore.

Smartphones used for brain scans

Most people probably associate the term 'brain scanner' with a huge machine at a hospital. However, thanks to an invention from a team of DTU Compute researchers, it will soon be possible to perform brain scans at home. To do so, users will need a smartphone, what is known as an EEG headset - a piece of equipment that is already familiar to computer gamers and which scans the electrical impulses in the brain. The researchers have developed an app with the capacity to analyse data from the headset and display them on a smartphone as a 3D model of the brain, with different colours used to highlight activation in different areas. The invention makes it possible to scan patients' brains in familiar, comfortable settings and thus opens up the possibility of epilepsy patients carrying out scans at home. Other users may be interested in keeping an eye on their stress levels. If you are looking to reduce your level of stress, a quick brain scan can help establish whether you are on the right track. The invention is still in the prototype phase, so the brain scan app is not yet available to the general public.

AppGarage - free play and innovation

At AppGarage, DTU students can give free rein to their creativity. It is all about inventing, designing, implementing and commercialising the apps of the future. AppGarage is what is known as a 'hackerspace', where students interested in developing and commercialising apps are given free rein to work on precisely the projects they consider most interesting. DTU Compute has built up a solid platform inspired by similar hackerspaces in Silicon Valley, with events centred on everything from business modelling to new programming technologies, and where students can receive support for their projects and personal development via a mentor network comprising entrepreneurs, investors and business managers.

In addition, AppGarage helps gather like-minded students together in 'tribes' to facilitate student-to-student learning. In this context, there are a gamer tribe, an iOS tribe, an Android tribe and so on. And yes, AppGarage is run by the students themselves. Naturally!

Why didn't the train brake in time?

In 2012, the Danish National Railways (DSB) was looking for help in explaining a disconcerting incident: an IC4 train had failed to brake as expected, overshooting a stop signal by more than 550 metres. It eventually came to a halt just 374 metres from a stationary freight train. As a result of this incident, all intercity trains of this type were immediately 'grounded'. DTU Compute coordinated the project and gathered more than 20 DTU researchers skilled in the fields of mathematics, computer science, electromechanical systems and risk analysis to look into the incident. After two months of concentrated work, the interdisciplinary group or researchers had developed a mathematical model of the train's braking system, which allowed them to simulate the incident from start to finish. The results were presented in a report which confirmed that the train security braking system worked as it was designed to. However, the researchers had identified a range of inappropriate factors in the design. At the same time, they established that the increased braking length was primarily attributable to low or almost non-existent adhesion between wheels and rails, probably on account of slippery rails. Largely on account of the report findings, the 'grounded' trains were allowed to start operating again.

3D Imaging Center - new national research flagship

In just a few years, the world's most powerful neutron source - the European Spallation Source (ESS) - and a unique source of x-rays (the MAX IV synchrotron) will be completed in Lund, Sweden. Together, they will provide unique opportunities to study all kinds of materials, boost fundamental research and industrial innovation, and stimulate the establishment of new technological enterprises. To ensure that both the business community and researchers make the very most of the future facilities in Lund, researchers from DTU Compute and DTU Physics have established a 3D Imaging Center in collaboration with partners including the Capital Region of Denmark, the University of Copenhagen and the Confederation of Danish Industries. 3D Imaging comprises methods for creating 3D pictures which we already know today from medical scanners. The use of 3D technology supplies the industry with unique knowledge about the measurement, calculation, improvement and quality assurance of products such as wind turbines. In addition to preparing for the measurements in Lund and a comprehensive strategic partnership with ESS and MAX IV, the centre will provide a range of services including consultancy, technical support, data analysis and teaching. The objective is for the facility to function as a shared international research centre and industry portal.
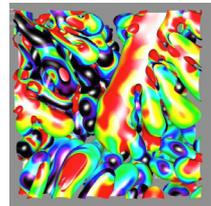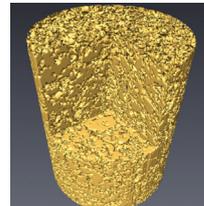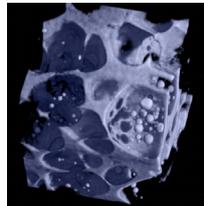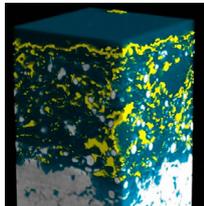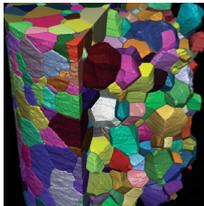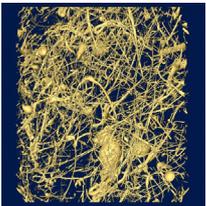
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