Grenoble INP - UGA is taking up the societal challenges represented by the four transitions: energy, environmental, digital and industrial, by combining the expertise in management and technological sciences at its schools and in the laboratories jointly supervised by the engineering and management institute. This collection turns the spotlight on leading scientists and innovative projects, technologies and products resulting from research carried out in the laboratories over the last two years.
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**BeFC: revolutionizing the world of electronics**

BeFC, a startup with its roots in Grenoble, has been a trailblazer in the world of energy conversion. With the support of various stakeholders, BeFC was created in May 2020. The company was founded by a team of scientists and researchers in the field of biocatalysis, with the primary goal of developing an eco-friendly energy source.

The startup’s innovative solution is based on the conversion of glucose and oxygen by enzymes similar to those found in the human body. This process can be used to create several milliwatts of electricity per square centimeter. Once activated by a few drops of liquid (water, blood, sweat…), the process lasts for several hours and the waste product left over is nothing more than a derivative of glucose that is also found in wine or honey.

This innovative solution relies on the conversion of glucose and oxygen by enzymes similar to those found in the human body. The process is perfect for powering portable devices that require milliwatts of energy. For example: integrated sensors on single-use medical patches, pregnancy tests, alcohol tests, or glucose monitoring kits for diabetic patients,” explains Jean-Francis. Several companies that would like to reduce their environmental impact as well as their recycling/waste disposal costs have shown strong interest for this innovative solution.

**3 million euros to launch industrialization**

BeFC was created in May 2020 with the support of the SATT Linksium. In July 2020, it was rewarded by i-Lab, an innovation contest organized by the French Ministry of Higher Education, Research and Innovation in partnership with Bpifrance. In August 2020, the startup also won the i-Nov ADME contest, and more recently, a prize as part of the “10,000 startups to change the world” contest, organized by the French Ministry of Higher Education, Research and Innovation in partnership with Bpifrance. In August 2020, the startup was also rewarded by l-Nov ADME contest, and more recently, a prize as part of the “10,000 startups to change the world” contest, organized by the French Ministry of Higher Education, Research and Innovation in partnership with Bpifrance.

With several patents to its name, this technology was initially developed at DOM and 3SR (CNRS, Grenoble INP, UGA), where the managing director of BeFC, Jean-Francis Bloch, worked as a researcher. The startup called upon his expertise in paper materials in order to develop its miniaturized solution that uses a paper base to support the enzymatic reaction. With 30 years of expertise in the field, Jean-Francis helped develop a thin, flexible, light-weight device that is free from metal, plastic and any toxic materials.

“Our patented technology to store fuel in paper enables us to produce energy with any fluid that serves to activate the biocatalytic cell. We also have another patent for a blister-like storage technique in which the user needs only press on the cell to activate it. This device is perfect for powering portable devices that require milliwatts of energy. For example: integrated sensors on single-use patches, pregnancy tests, alcohol tests, or glucose monitoring kits for diabetic patients,” explains Jean-Francis. Several companies that would like to reduce their environmental impact as well as their recycling/waste disposal costs have shown strong interest for this innovative solution.

**Maintenance for electrical networks is a real headache!**

Maintenance for electrical networks is a real headache! In addition to the difficulty of accessing cables that are either underground or in the air, there are simply more than 100,000 km worth of high and very high tension lines plus 1.3 million km worth of high and low tension lines. As a result, maintenance is organized around a pre-planned schedule which is currently insufficient to prevent rather frequent electrical failures.

Cornel Ioana, a lecturer at Grenoble INP - Ensa, UGA and a researcher at GIPSA-Lab, led the creation of Altrans. The startup is now responsible for continuing the technology’s development through commercialization and operation.

**Translocator is a detection system for emerging faults in electrical networks.**

This patented innovation won the Grip’Up prize (ENedis) in May 2017. Following the prize, Cornel Ioana continued developing the system as part of the SATT Linksm incubation program. The system was finalized in 2018 and took steps to explore and understand global market needs in order to develop a product.

“The system is based on technology that is capable of detecting temporary faults in an electrical network (e.g., electrical arcs and stocks). The detection is automatic and autonomous,” explains the researcher. The detection sensors are non-intrusive and self-charging thanks to an energy system that reuses energy present in the lines. The sensors send fault information to a central module which models the data in order to locate the origin of the problem.

“The lab provided a fundamental innovation in terms of how to analyze signals thanks to a mathematical tool that performs as a sort of magnifying lens. Algorithms and software were created to analyze temporary electromagnetic phenomena and determine whether or not these signals were normal or an indication of a fault.”

Officially created in November 2020, Altrans is continuing its partnership with ENEDIS. The startup has begun installing sensors on a few network segments. The data is then collected and analyzed in Grenoble. In partnership with EDF, Altrans is working to certify the operational reliability of its product. “With their support, we have access to the only true scale model of the network, which enables us to test all possible faults and ensure our tools are able to detect and locate them.” With such promising results, Altrans is already aiming to conquer markets in Canada and China. All the best of luck to them! *Grenoble INP, CNRS and UGA*
Synchrotron shines light on fuel cells

Following a 20 month break to upgrade its systems, the European Synchrotron Radiation Facility (ESRF) was rebooted on Tuesday, August 25. With performances 100 times higher than the old system, the ESRF is now the world’s most powerful x-ray source. And what will this powerful x-ray source be used for? The field of fuel cell research offers a recent example. In addition, the sector will benefit from government support thanks to a plan presented on September 8.

The new Grenoble synchrotron offers an x-ray source 10,000 billion times stronger than a hospital x-ray. Following an upgrade plan that lasted almost two years, this high-performance installation opens the door to a better understanding of complex materials and living materials. The ESRF-EBS (Extremely Brilliant Source) creates a beam of electrons that is 2 micrometers high and 20 micrometers large (30 times thinner than the previous version). The beam travels at speeds nearing lightspeed and produces even brighter x-rays that can dissect material on the smallest of scales (down to the nanometer level). This upgrade changes everything for researchers such as Raphaël Chattot, who is doing his postdoctoral research at the LEPMI (CNRS, Grenoble INP - UGA, Université Savoie Mont-Blanc) and the ESRF. Thanks to the ID31 x-ray beam, he is able to design electrodes for higher performance fuel cells.

Optimizing fuel cells

Developing hydrogen technology and fuel cells is part of the process required to create a carbon-free energy system. Hydrogen produced by the electrolysis of water reacts within the fuel cell to create electricity that can power an electrical motor with water as its only output. Within the fuel cell, hydrogen reacts with oxygen. The oxidation and reduction reactions are catalyzed by platinum, a very expensive material that deteriorates over time.

The research work carried out by Raphaël Chattot and his colleagues at the LEPMI and ESRF aims to use platinum in a manner that offers greater performance and durability. “To reduce the quantity of platinum required for an electrode, we use it in the form of nanoparticles. However, these particles don’t keep their properties for as long as the fuel cell life cycle. There are crystalization defects that appear over time and have an impact on the system’s performance. And lowering the overall activity of the catalyst over the short-term actually increases local activity in terms of certain defects,” explains Raphaël Chattot.

To create materials that are both high-performing and durable, researchers need to find the ideal compromise by inserting beneficial structural defects when designing the nanoparticles. To achieve this compromise, researchers need to correlate the creation of a certain defect with a particular performance. This is where the ESRF-EBS comes in. The nanoparticles are bombarded with x-rays which enables researchers to view their crystalline structure. The more powerful x-rays delivered by the new synchrotron will enable researchers to observe materials directly within the electrode as it operates and thus understand the relationship between structure and performance in real-time.


Does pollution aggravate the Covid epidemic?

Is there a connection between pollution and the spread of coronavirus within the population? It would seem so. At least, that is what is suggested by a recent study published by Italian researchers in collaboration with Giogrio Licciardi, a researcher at GIPSA-Lab*, and Jocelyn Chanussot, a professor at Grenoble INP - Ense3.

In light of the observation that some regions showed a higher-than-average infection rate, scientists in a team led by Roberto Dragone, a researcher at the CNR-ISMN (Istituto per lo Studio dei Materiali Nanostrutturati - Institute for the Study of Nanostructured Materials) wanted to know what the cause of such inequalities might be. The hypothesis put forward by various experts is that the presence of air pollutants and weather conditions such as temperature, humidity and wind speed, may affect the stability.

During the study, the researchers examined the case of Lombardy, which concentrated 40% of the country’s infections during the first wave of the epidemic and had a higher rate of infection increase than the rest of the country**. They analysed epidemiological data from the 12 provinces of Lombardy, provided by the Superior Institute for Health and Civil Protection. For the period analysed, it was shown that over 63% of the infected people recorded across the region were concentrated in the provinces of Milan, Bergamo and Brescia. More generally, the average infection rate in Lombardy was twice as high as the national rate, which was at 0.21%.

The researchers then compared these observations with meteorological data on temperature, humidity and wind speed recorded daily by weather stations throughout Lombardy, as well as satellite data on daily concentrations of air pollutants (nitrogen oxides, carbon and sulphur monoxide, ozone and ammonia). “It seems clear that high pollution levels favour the spread of the virus,” says Jocelyn Chanussot. “This can probably be explained by the fact that the virus spreads by attaching itself to airborne pollutant particles”. In any case, this confirms that the virus is indeed transmitted by air and not only by contact, as was thought at the beginning of the epidemic. Other studies have since confirmed this hypothesis.

*CNRS, Grenoble INP - UGA, UGA
** It is important to note that, during the period studied, it was not compulsory to wear personal protection outside in Italy.


* The new source produces many more photons per time frame which increases the speed of image acquisition. The source is also thinner than the previous one and enables greater precision when imaging electrocatalytic layers that are only a few micrometers apart when viewed within the fuel cell. This type of ex-situ study is essential if this technology is to be developed beyond the laboratory,” highlights Raphael Chattot. Thus the new source enables researchers to collect much finer images of high-speed phenomena taking place within systems that are up and running. It’s an improvement that will offer much new information for a variety of fields of research.
Tuil’Up, the ecological roof

In mid-March 2021, a new generation of roof tile appeared on the shelves in certain DIY stores: Tuil’Up. Developed by the start-up Celloz with the scientific support of LGP2*, it offers a more environmentally-friendly alternative to the plastic, metal or asphalt products currently available on the market.

Having spent 20 years in the petroleum-based roofing industry, François Ruffenach, head of Celloz, wanted to do something to help the environment. After deciding to propose an alternative solution based on cellulose, he approached the researchers of LGP2 during a convention in 2016 to ask them to help him develop his project. “The basic idea was to propose moulded cellulose roofing made of 100% recycled fibres,” says the entrepreneur. “These are suspended and then shaped by thermo pressing during a stage to remove the water, a bit like with egg boxes”.

The problem is that cellulose is not waterproof. The product therefore had to be made water resistant using various treatments in order to make effective tiles. This is where Céline Martin, a lecturer at Grenoble INP - Pagora and a researcher at LGP2, came in. “We developed a process that involves soaking the initial fibrous composition in bio-based resins and coating the surface of the finished product with a thin layer of paint,” she explains. “The end result is a material that is 92% renewable”. The rest was a question of ongoing product improvement thanks to different sources of funding (ILab in 2018, fundraising in 2020, aid from the Aquitaine Region and the BPI etc.)

Three years after its creation, the start-up recently presented the first Tuil’Up products on the shelves of certain DIY stores. “For the moment, we are targeting the secondary roofing market, such as for garden sheds,” explains François Ruffenach. “That is still 7 million square metres of roofing installed each year in France alone!” Roofing elements for ancillary buildings are not subject to the same requirements in terms of fire resistance and other certifications as roofing for residential buildings. In parallel, the start-up is continuing its R&D work in partnership with LGP2 to increase the lifespan of its products and in particular their fire resistance. “Once the performance targets are met, hopefully by mid-2022, we can hope to obtain certification for our second generation of products and tackle the roofing market for residential and commercial buildings.”

*CNRS, Grenoble INP - USA

Predicting ice melt in Antarctica

The LEGI* Coriolis platform was used to help study the impact of ocean currents on ice melt in Antarctica. The results were published in Nature.

Several observations by satellite have confirmed that Antarctica’s ice sheet has been losing mass at a highly accelerated rate over the past couple of decades. Unlike glaciers in the Alps or Greenland, air contact ice melt is negligible in Antarctica. Instead, it is agreed that ice melt is mostly happening through contact with water. Antarctica’s land-based glaciers feed into large floating ice sheets on the ocean. Melting caused by contact with the ocean encourages further glacier flow towards the ocean.

The ice sheets around Antarctica are more than one kilometer thick and end as ice cliffs that dominate the ocean. However, ice melt has been occurring at a heterogeneous rate around the continent. As a result, a team of Swedish, Norwegian and British researchers implemented a project to better understand this phenomenon.

The importance of ocean currents

While surrounding seawater may be only a few degrees above freezing, ocean currents are sufficient to melt the underside of Antarctica’s ice sheet. This ice melt weakens the ice sheets and contributes to their break up into huge icebergs.

A better understanding of these currents helps scientists anticipate ice melt and the resulting increase in ocean levels. By the end of the century, ocean levels could increase by up to one meter. But observing this change is quite a difficult task. As a result, the researchers called upon LEGI skills in order to simulate water currents using the Coriolis platform. “This rotating tank is 13 meters wide and can reproduce a small scale version of phenomena that take place in oceans. The characteristic canyons in oceans surrounding the Antarctic region were imitated and placed at the bottom of the tank. Colored water was then injected into the tank and observed using a laser. Different density levels were tested by varying salt levels while the rotation of the tank imitated the effect of earth’s rotation,” explains Joël Sommeria, director of LEGI.

Fine-tuning ocean current models

The research results recently published in Nature enable scientists to better understand the convection and heat transfer mechanisms present in these ocean currents and how they impact currents passing under an ice sheet. “When water density is constant, the current is blocked deep under by the edge of the ice and moves around the ice sheet. When a heterogeneous liquid density was used, we observed that dense water was no longer blocked and could travel under the ice sheet.” The results from the Coriolis platform demonstrate that the quantity of water flowing under an ice sheet depends on several water current factors: speed, differences in density, and the shape of the ocean floor and ice sheet.

These results have already enabled researchers to fine-tune ocean current models and better target their measurement activities. Over the long-term, these results will help better predict the risk of a major acceleration in ice melt due to global warming.

To learn more: Read the article on the Nature website
Read the article on the LEGI website

*Laboratoire des Ecoulements Géophysiques et Industriels (CNRS, Grenoble INP, USA)
**MATERIALS**

**Clara Aimar's recipe for polymer foams**

A graduate of Grenoble INP - Phelma, UGA and a PhD student at 3SR*, Clara Aimar recently won first prize in the “My Thesis in 180 Seconds” competition during the Alps final. Her work focusses on polymer foams for sports shoes with Decathlon.

Her presentation on foam, whether culinary or polymer-based, was a success. Clara Aimar is currently in her second year of a PhD at 3SR and was recently awarded first prize at the Alps final of MT180 on 9 March this year. The young researcher, who joined Grenoble INP - Phelma, UGA after a two-year preparatory course at Toulouse INP to pursue her love for materials, currently works on the polymer foams used to make soles for sports shoes.

It was during an internship at Decathlon, carried out as part of her engineering degree project, that she decided to continue her work through a PhD on the same theme: making polymer foams more resistant to repeated mechanical stress so that shoes protect sports players better and for longer. “Runners' health is at stake, but also that of the planet,” explains Clara Aimar, who is concerned about reducing waste. “Currently, the best shoes are worn out after 1,000 kilometres of running. This figure should ideally be multiplied by two, and then ten.” To achieve this, the researcher is working on optimising the “recipes” of these foams (nothing to do with haute cuisine), by addressing the ingredients, formation processes, “cooking” temperature etc. She hopes to obtain new textures to improve the mechanical properties of the foams, which then have to be tested before the industrialization stage.

**Chaotic beginnings**

Things didn’t start well… around a year ago, the laboratory where she worked was destroyed by a fire, just three months after the start of her PhD. “All the machines on which I had started setting up some operations went up in smoke,” she explains. It was a tough blow, but the student didn’t give up hope. She used this period of several weeks of forced separation from the laboratory to work on her bibliography and prepare the analysis of future results. Today, most of the machines have been replaced, thanks to the financial support of the CNRS, Grenoble INP - UGA and the University, which jointly supervise the laboratory, and Clara has been able to resume her experiments.

Alongside Maxime Leprince, a PhD student at CERMAV (CNRS) and CEA-LETI, Clara will be representing the “Grenoble Alpes Savoie Mont Blanc Universities” group at the national semi-final of the MT180 competition, organised in France by the CNRS and the CPU. While waiting for the results, she will be closely monitoring the work of her fellow competitors in other regions. Good luck!

To find out more: follow the next stages of the competition at [https://mt180.fr/](https://mt180.fr/)

*CNRS, Grenoble INP - USA, UGA

**Vulkam: a SIMaP success story**

The startup Vulkam was launched from the Simap* laboratory and is a growing success story. Thanks to amorphous metals with unique properties, the startup can meet emerging industrial needs and open the door for smaller components.

“By changing the atomic organization of a material, we fundamentally change its properties,” explains Sébastien Gravier, founder of Vulkam, a DeepTech startup he created to commercialize new materials with unique properties. Following a thesis on amorphous metals at the SIMaP laboratory and 10 years as a teacher at Grenoble INP - Phelma, UGA and a lab researcher, Sébastien decided to launch a project to valorize these interesting and unusual materials. With the support of the SATT Linksium, he was able to launch the project in June 2017.

The startup's only competitor is specialized in large components, whereas Vulkam is specialized in miniaturization, which is more “profitable from an economic point of view”. The startup developed a range of materials specifically adapted to meet the needs of industry (Vulkalloys®). “One of our leading products is an ultra-insulating thermal material that was developed for LynRED (ex-Sofradir) to support their infrared sensors. Thanks to atomic modifications, we offer materials that are twice as insulating as existing materials. This enables us to reduce the required space for a component thanks to smaller insulation needs, or instead, to halve the energy consumption of a device,” explains Sébastien. Weight reduction thanks to these innovative materials can also be of use for sectors such as aeronautics, space exploration and defense. The Vulkalloys® product range also offers flexible materials using copper for timekeeping devices as well as biocompatible zirconium alloys that are 1.5 times more resistant than titanium based materials used for miniaturized surgical components. “For example, we produce specific pliers for cataract surgeries, which count for 850,000 surgeries a year in France!” The latest Vulkalloy® to be developed by Vulkam is a nickel based alloy that is simply the most resistant material that exists! With its strength and resistance to friction, the alloy could be used in watchmaking or medical industries.

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Vulkam not only developed its range of materials but also the equipment necessary to manufacture the materials on a small scale. “We currently offer industries the possibility to produce specific materials to meet their needs and test prototypes.” Thanks to funds raised at the end of 2019, the startup will be able to expand its manufacturing line. The startup currently employs 20 people and aims to scale up production by the end of 2022.

*CNRS, Grenoble INP - UGA
Cellulose and ceramics unite... for improved packaging!

The HANAbi project is being implemented by the SiMAP* and LGP2** laboratoires. The goal is to combine the advantages of paper and ceramics in order to keep the best of both worlds and create an alternative to plastic packaging.

Every year, 7 million tons of plastic end up in the ocean. Once dumped in water, plastic packaging, bottles and labels cannot break down completely. Instead, they turn into microparticules that can be found everywhere. Reducing this waste is a major environmental challenge.

To replace plastic food packaging, researchers at Grenoble INP - UGA were able to combine technology for two materials that were previously considered to be incompatible. The first of these materials is cellulose, which is studied at LGP2. "While paper has the advantage of being flexible and biodegradable, it also lets through water and gas. On the other hand, ceramics, which is studied at SiMAP can be both waterproof and gas-proof. But not very flexible," explains Erwan Gicquel, a postdoctoral researcher at LGP2, who is working on the project with Frédéric Mercier, a CNRS researcher at SiMAP.

As part of a project funded since 2018 (Labex CEMAM and Tech 21), the two scientists developed a hybrid material made up of 99% cellulose. "By adding just enough ceramic material in the right place using a secret bonding process, we are able to obtain a 99% cellulose material that has the advantages of plastic (waterproof and gas-proof) all the while being flexible and printable like paper", explains Frédéric Mercier.

Several patents are being filed in order to protect the bonding process for combining cellulose and ceramics. This will enable the project to transition to large-scale, low cost production. A startup project called HANAbi is currently being established via the SATT Linksium and should be ready to go in the Fall of 2021. Several players in the food industry have already expressed interest in the project (for example, to replace wine labels). But the “zero plastic” HANAbi is also targeting other markets such as packaging or construction, where it could be used for isolation and benefit from the flexibility and lightness offered by cellulose.

*CNRS, Grenoble INP - UGA, UGA
**CNRS, Grenoble INP - UGA

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PaperTouch, Grenoble INP - UGA and the CNRS invent interactive, touch sensitive and recyclable paper

Researchers at LGP2* recently developed an interactive paper material that reacts to one’s touch or breath and can record and transfer data thanks to an integrated electronic circuit. This innovative paper can even light up.

LGP2, which is affiliated with the school Grenoble INP - Pagora, UGA, is currently working to produce and commercialize PaperTouch by creating a startup that will be hosted within the Paper Processes Engineering Lab (Génie des Procédés Papetiers) and incubated at SATT Linksium.

The launch of the startup is being led by Fanny Tricot, a Grenoble INP - Pagora, UGA graduate who is currently doing her postdoctoral work at LGP2.

A paper with unique functionalities

PaperTouch paper contains sensors that react to one’s touch or breath as well as connected antennas that react to any nearby smartphone with NFC technology. The energy created by the signal lights up ultra-flat LEDs within the paper and enables a smartphone to access data stored within the paper’s integrated electronic tag.

This new technology offers many potential applications. For example, researchers at LGP2 developed multi-functional, luminous and interactive packaging geared for the luxury and cosmetics industries. They also created a paper keyboard that reacts to a user’s breath and could facilitate interactions with electronic devices for users suffering from paralysis.

PaperTouch could also be used for domotics by creating wallpaper with tactile sensors that would replace control panels in smart homes.

Bio-sourced and recyclable materials

PaperTouch is primarily made up of bio-sourced cellulose fibers that ensure this interactive material is compatible with paper/cardboard recycling procedures. The electronic circuit is sandwiched between two wet pieces of paper which become a unique piece of paper upon drying. At the end of its life cycle, PaperTouch has no adhesives. When soaked in water, its cellulose fibers separate from the electronic components and break up.

Research at LGP2 focuses on the transformation and valorization of organic biomass (e.g., bio-refineries), the creation of bio-sourced materials (paper, cardboard, composite materials, films, non-woven materials, etc.), and printing processes to add functionalities to various surfaces. Researchers also study processes that use less energy and raw materials in order to implement green chemistry for functional materials.

The LGP2 team includes 21 permanent researcher staff and 35 doctoral, postdoctoral and temporary team members. On average, the lab files 7 patents per year.

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*Mémoire Génie des Procédés papetiers (Agefpi), CNRS, Grenoble INP - UGA
**Laboratoire Génie des Procédés papetiers (Agefpi), CNRS, Grenoble INP - UGA
Plastic film for better network reception in buildings

Launched in March 2021 after incubation at SATT Linksiusm, the Lichens start-up uses a process from IMEP-LAHC* to improve telephone network signal reception in buildings, without losing thermal insulation quality.

Do you lose your signal as soon as you walk through your building’s front door? This is probably due to heat-insulated windows and other new advanced materials used to optimize the energy efficiency of buildings and meet new standards. These inevitably lead to a reduction in the transmissibility of waves of all kinds, including sound and electromagnetic waves such as those used by smartphones.

To resolve this issue, the Lichens start-up has found a solution that comes straight out of IMEP-LAHC. “We had already developed and patented paper coatings that could block waves such as wifi,” explains Tân-Phu Vuong, a lecturer at Grenoble INP – Phelma, UGA and a researcher at the laboratory. “We had the idea of doing the opposite and using the same technical processes to facilitate the passage of the waves and regain signal strength. To do so, we used the frequency selective surface (FSS) process, which consists in printing patterns using conductive inks on plastic film,” continue François Vincent and Olivier Vandesmedt, two engineers with a background in industry and the founders of Lichens. The film is intended to be simply placed on the window and glued by the adhesive power of plastic film. “These patterns favour the passage of certain frequencies by resonating with the conductive layer of the glass.” They enable an increase of at least 10dB for the desired frequencies and improve signal reception inside buildings.

An easy and removable solution

This solution is highly innovative and much less expensive than laser engraving the glass or active solutions that need to be powered by energy to function. The panels are removable and can be peeled off when cleaning or replaced with a more efficient version when the time comes.

This product is mainly aimed at small tertiary buildings and is expected to arrive on the market in 2022. “We are currently working to improve the visual aspect of the device, such as more discrete patterns or a greater transparency of the ink used to draw them.”

The aim is to make the network available in a 20m2 room with a 50 cm X 50 cm adhesive panel. Once the product is ready, it will be produced on an industrial scale in partnership with Arjowiggins. In the meantime, trial films for an easier passage of specific frequencies are available for testing.

Mathieu Desbrun brings objects to life

Having recently joined the Inria centre in Saclay, Mathieu Desbrun, a graduate of Grenoble INP - Ensimag, UGA, has been recognised by the Association for Computing Machinery for his contribution to computer science.

When watching a Pixar animation, we have all wondered how the princess’s hair or a creature’s fur came to be so realistically animated. In fact, years of research in computer graphics lie behind this feat, and many mathematical models are used to animate these types of objects in the most natural way possible. This is precisely the job of Mathieu Desbrun, a teacher-researcher in applied geometry at Inria and a 1994 graduate of Grenoble INP - Ensimag, UGA.

As a young engineer, Desbrun was passionate about computers and fascinated by fractal images: mathematical objects with effects that are often considered hypnotic, and very quickly turned to 3D computer graphics. After obtaining his degree, he began a thesis with Marie-Paule Cani on highly deformable objects at the former IMAGIS laboratory in Grenoble, followed by a post-doctorate at Caltech in the USA. He remained there for 23 years as a professor in applied geometry, a term he himself coined to emphasise the importance of applications in his research.

Cinema, vehicles... and many other fields

What is the purpose of his research? “To describe and animate virtual objects in time according to their environment,” he summarises. “There is a whole market that needs to render realistic animations with the least amount of computing time. For a film, we need to produce 60 images per second, for 1 hour 30 minutes!” The art of the computer scientist is to find a way to make these calculations as quickly as possible to generate the objects, animate them and obtain a natural visual rendering. To do this, Mathieu Desbrun relies on discrete differential geometry, which allows him to numerically reproduce the fundamental equations that model the world around us.

Beyond film, this research is useful in many other areas. “For example, we can provide tools for car designers to test the influence of a car’s shape on its aerodynamics in real time,” explains the researcher. “Or to simulate the influence of helicopter blade design on noise and lift in real time. Or to model certain organs of the human body and the blood system.” Back in France, Mathieu Desbrun - on indefinite leave from Caltech - has just joined the Inria Saclay - Île-de-France centre as an advanced researcher, and the LIX (École Polytechnique’s computer science laboratory) as a teacher.

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Grenoble prepares the quantum revolution

A French deputy, Paula Forteza, who is a specialist of digital subjects, recently submitted a report suggesting the creation of three hubs for quantum computing in Paris, Saclay and Grenoble. A proposal that sits well with the Grenoble CDP* Quantum Engineering, which has been working for the past three years to coordinate local actors.

While traditional computing relies on data that is coded using bits (a state of 0 or 1), quantum computing is built on quantum bits, or “qBits”, which can simultaneously take on the value 0, 1 or any infinite number of states between 0 and 1. This change completely revolutionizes computing.

The scientific community in Grenoble is ready to launch this revolution both in terms of research and education. The various skill sets necessary for this field are coordinated by the Quantum Engineering CDP that was launched three years ago and is funded by Idex (QuEnG). In terms of hardware, qBits are being developed at Leti (CEA), IRIG (CEA/UGA) and Institut Néel (CNRS). “Grenoble has a history of expertise on the subject of qBits and the various materials used for quantum computing. There are various types of qBits: spin (electrons, molecular instances), photonics (polarization of unique photons), or supraconducteurs. Grenoble is also a leading proponent of the spin qBit composed of an electron in silicon, which is compatible with CMOS manufacturing,” explains Alexia Auffèves, CNRS research director at Institut Néel and coordinator of the CDP.

From hardware to software

Mehdi Mhalla, CNRS research at LIG (CNRS/Grenoble INP - UGA/Inria/UGA), is working on the software side of things for the CDP. He studies how quantum computing will change our use of data. If we demonstrate the ability for a quantum computer to perform all actions carried out by a normal computer, the superposition** phenomena will accelerate the speed of calculations. “It’s possible to carry out very complicated calculations with much fewer steps than required by a classical computer. If you need n steps with a classical computer to solve a search problem in a database, then you need √n to solve the problem quantically,” explains Mehdi Mhalla. Quantum solutions could be particularly useful for extremely complex problems in which the enormous amount of data required is too much for even a classical supercomputer to handle. “For example, the algorithm discovered by Shor in 1994 could factorize a whole number into two prime numbers at record speeds. This would make it possible to hack security keys used for bank transactions,” adds the researcher, who also teaches quantum cryptography to students in the Grenoble INP-Ensimag, UGA and UFR IM2AG Cybersecurity master’s degree.

Forteza’s report also reminds us that the development of quantum technology will require changes in education for future quantum engineers. The CDP has positioned itself on the cutting-edge of this change by inspiring and supporting a project based on inverted education methods. This new educational project offers small, multidisciplinary groups of students, physicists and computer engineers to access and code quantum algorithms on IBM’s processor (IBM is the sponsor of Grenoble INP-Ensimag’s latest graduating class). Such educational experiences are the first steps towards true multidisciplinary programs that will draw on the full potential of the Grenoble ecosystem. Traditional industry partners such as STMicroelectronics, SOITEC and ATOS are also closely monitoring all advances made in the field of quantum computing.

*Cross Disciplinary Program

** An introduction to quantum physics to facilitate understanding

The first quantum computing theories were developed in the 80s and relied on the surprising characteristics of quantum physics. When dealing with the infinitely small, matter no longer follows the rules we usually apply. According to the mechanics of the infinitely small, an object can be in several states at once and is in an undetermined state until it is measured. As a result, an electron can be in different places and move at various speeds at the same time. Or a photon can simultaneously have two types of polarizations. This is known as the superposition theorem.

Another important concept is that of quantum entanglement. This principle explains that two quantum objects that are apparently independent can be forced to link. For example, they can be forced to be in opposite states at the time of measurement. If no information is exchanged between the two particles, they are linked not as two separate, independent systems, but as simply one system. Therefore, in quantum physics, we can link several systems that appear to be independent and far away from each other. As a quantum state can always be extended at microscopic levels, we can play with all of these possibilities using simple, cold, isolated atoms.
Dust clouds reveal new information about the birth of stars

Thanks to artificial intelligence, astrophysicists were able to better understand a lasting secret of the universe: how stars are born.

How are stars born? Until recently, the question was difficult for astrophysicists to answer because the hydrogen that makes up stars is not detectable in its molecular form at the very low temperatures found in the dust clouds from which stars are born. However, experts in the field of signal and image analysis were able to unite their forces as part of the ORION-B program (in reference to a famous dust cloud) in order to set up new techniques using artificial intelligence that can help solve this mystery.

While hydrogen cannot be detected, these dust clouds contain other tiny dust particles and molecules that can be traced. For example, CO can be found in an approximate proportion of one CO molecule for 10,000 hydrogen molecules. By itself this information is imprecise, but when combined with other molecule proportions researchers are able to estimate the quantity of hydrogen present in a cloud. However, this is where things get complicated because physicists were faced with the extremely complex physics and chemistry mechanisms that govern the connections between molecules. 

As part of the ORION-B program led by IRAM (Institut de Radioastronomie Millimétrique), a group of researchers including Jocelyn Chanussot, a researcher and professor at Grenoble INP - UGA in the GIPSA-lab**, were able to develop new methods using artificial intelligence and deep learning in order to study the observations of clouds across a spectrum of 240,000 light frequencies. In concrete terms, this allowed them to render usable hyperspectral*** images obtained via radio telescopes that target the Orion cloud. “The raw images are full of noise much like when you watch a tv that doesn’t receive a specific channel. However, useful information is hidden within all this noise. To use it, you have to get rid of the excess noise,” explains Jocelyn Chanussot.

This is a complicated task as the noise can vary from one pixel to another and sensors move in the interval between two images. As a result, classical algorithms to reduce noise cannot handle the task. By analysing the data from dedicated artificial intelligence algorithms, the ORION-B researchers were able to access information that was heretofore inaccessible. These calculations notably enabled them to precisely estimate the quantity of hydrogen and free electrons in the cloud without having to observe them directly. These two factors play a major part in guiding the mechanisms that control the birth of stars.

Defining the quantity of material available in a cloud for star formation is only the beginning. Another challenge is to extract data about the movement of material in order to further understand the collapse of gas during the creation of a star.

The LEGI’s (CNRS, Grenoble INP - UGA, UGA) expertise in fluid mechanics was put to good use in order to understand how Covid-19 spreads.

Turbulence is a natural aspect of complex flows such as those surrounding eoliens or water flow in a hydraulic turbine. And of course, they are also part of the air we breath!

The air we breathe is one suspected means of spreading Covid-19. What happens when your neighbor sneezes or simply breathes near you? Micro-droplets containing the virus can be expelled and float through the air, making it possible for someone to breathe them in. To better understand this phenomenon, LEGI researchers were contacted by colleagues at TIMC (CNRS, CHU Grenoble Alpes, Grenoble INP - UGA, UGA, VetAgro Sup) in order to “Evaluate the risks presented by this form of transmission and the efficiency of preventive measures used in a variety of contexts. Digital simulation offers an efficient means to evaluate the situation as long as we are able to reliably reproduce the physics of the phenomenon,” explains Guillaume Balarac, lecturer at Grenoble INP - Enset, UGA and a LEGI researcher.

Particles and turbulence

With their strong expertise on fluid mechanics, and in particular turbulence, the researchers analyzed the impact of turbulence on particles floating in the air. With the current crisis, their research work was carried out in collaboration with colleagues from CORIA, IMAG, Vermont University and SAFRAN Group, and their analysis was able to benefit from 10 million hours of calculations on the Joliot-Curie supercomputer located at CEA Paris-Saclay!

A fluid’s behavior is governed by the Navier-Stokes equation, which intrinsically includes turbulence. Turbulence is a phenomenon that is active throughout a wide range of spatial scales. To reduce calculation times, smaller scale turbulence is described using a simple, universal model. Large-scale turbulence is simulated through calculations, while smaller ones are modeled. This approach, known as large-scale simulation, greatly reduces calculation time while ensuring sufficient accuracy.

The researchers used this method, which is integrated in the YALES 2 calculation code, to study the path of droplets according to their size, external air flow (ventilation), etc. “The results, which are still being collected and analyzed, could help evaluate the efficiency of protection equipment such as visors.” However, for the result to be useful, they will also need to be analyzed by experts in biology and virology in order to extract concrete, applicable conclusions.
Improving our understanding of language and its mechanisms

A team of researchers from Grenoble and Canada demonstrated for the first time that a speaker is able to identify the vowel being pronounced simply thanks to somatosensory feedback based on tongue shape and position.

If you randomly position your tongue, would you be able to guess which vowel will be pronounced before making a sound? The answer is yes according to the results produced by a multidisciplinary team of experts in Grenoble (Gipsa-lab* and LPNC**) and two Canadian teams, including Professor David Ostry’s team at McGill University in Montreal. Despite their rather logical outcome, the findings were apparently not so obvious at the start of the project.

To reach this conclusion, the researchers used a clever experimental protocol. **”We placed small sensors around the tongues of volunteer participants. We then asked them to move their tongues to certain positions using a visual feedback system that enabled them to point their tongue at a specific target much like a joystick,” explains Jean-luc Schwartz, CNRS research director at Gipsa-lab and co-author of the research published in **PNAS**. “Once participants were able to position their tongue as required, they were asked to guess which vowel would be produced by their tongue shape without making any noise. In general, they were able to predict the right vowel just as efficiently as if they had heard the vowel pronounced.”**

In order to test somatosensory feedback without the aid of spoken sounds, researchers could have used a device to hold and move the participant’s tongue. To avoid this uncomfortable approach, they had to create a sophisticated experimental protocol that was much more comfortable for participants.

Illustration: Sandra Riechard©

Each tongue position matches a sound

These research results indicate that our brain is able to collect and analyze somatosensory data based on the shape of a tongue and a related language. **“While we speak, we not only produce sound, but also create a specific tongue shape that impacts the shape of our vocal track and this is what creates characteristic sounds useful for spoken language,” adds Pascal Perrier, a professor at Grenoble INP - UGA, a researcher at Gipsa-lab and co-author of the PNAS publication. “Thus, when we speak we also create somatosensory feedback that is part of fundamental information, in addition to sound, that enables us to control the quality and accuracy of speech.” While these findings are of great interest in theoretical terms, they also open the door to interesting possibilities in terms of rehabilitation for children suffering from speech disorders or adults who partially lose their hearing. For children, learning is so efficient that somatosensory feedback could enable them to grasp accurate speech and tongue movements without having perfect auditive feedback.

Improving artificial language models

In more theoretical terms, this new knowledge will enable researchers to further develop models for speech production. It will help researchers pilot complex physical, biomechanical and acoustic models for speech simulation. With these models, it is possible to simulate the creation of sounds by controlling specific tongue muscles. A simplified biomechanical probabilistic model that simulates the effect of primary tongue muscles on the vocal tract was developed by Jean-François Patri, head of the chair and also co-author of the publication. This probabilistic model could be inserted in artificial intelligence applications in order to efficiently integrate muscular simulation, tongue shapes and sounds for machine learning. This research work is being developed under the framework of the Bayesian Cognition and Machine Learning for Speech Communication Chair led by Pascal Perrier at the MIAI Grenoble Alps Institute. A major goal for the chair is to generate machine speech using artificial intelligence tools that would simulate human speech patterns in humanoid robots.

** LPNC, Laboratoire de Physiologie et NeuroCognition, CNRS, UGA
** GIPS-lab, Grenoble Images Parole Signal Automatique, CNRS, Grenoble INP, UGA
**LINGO, Laboratoire de Linguistique et Organisations, ENS Lyon, CNRS, UGA
**GIPS-lab, Grenoble Images Parole Signal Automatique, CNRS, Grenoble INP, UGA
** LINC, Laboratoire de Linguistique et Organisations, CNRS, UGA
** IPID, Génie industriel, UGA, Grenoble INP - UGA

BUSINESS & SOCIAL SCIENCES

Business: How are companies dealing with the Covid-19 crisis?

The Covid-19 crisis has turned many industrial and logistics organizations upside down. The primary focus on profitability has been replaced by the need to ensure the health of workers while maintaining sufficient activity to meet demand and preserve the business.

To better understand this situation, researchers are studying how organizations are adapting to this change. Thomas Reverdy, a social and human sciences teacher at Grenoble INP - Génie industriel, UGA and a researcher at the PACTE laboratory, is currently collaborating with Axel Genevois, a research project manager, to collect 50 testimonials from managers, engineers and technicians in Grenoble INP - UGA’s continuing education program “Sustainable industrial performance engineering” (EPD) as well as input from the school’s alumni. “While the media have spoken a lot about the fact certain companies have completely reorganized their production chains to produce masks, visors or hydroalcoholic gel, this is only the tip of the iceberg. In all fields of activity, companies have had to re-organize their activities,” underlines Thomas. The industrial and logistics activities, which are both material and human oriented, have been highly impacted. However, few have completely stopped their activities in the Grenoble region, microelectronics, electronics manufacturing and chemistry factories have all continued their production while adapting their priorities to match the current situation.

Differing perspectives on risk thomas reveryd

One of the primary findings from the study carried out by Thomas Reverdy and Axel Genevois is that within each company there are differing perspectives on risk. Depending on an employee's position (worker, manager, director...), the threat of the virus and its impact are not perceived in the same manner. On the management side, people tend to be highly invested in managing the risk of a company’s economic survival (loss of demand, supply problems, supplier relationships...). On the other hand, worker teams and their field managers tend to be more invested in preventive measures and ensuring employees are protected and reassured vis-à-vis the sanitary risk caused by the virus. “Each person has a different perspective on the various risks at play. Some people believe in the importance of continuing the business activity and respecting commitments made to clients while others believe that during a time of crisis, only vital operations justify exposure to contamination,” highlights Thomas in his study***. In other words, each actor’s beliefs and perception of the virus and the risk of contamination determines how they accept or implement actions and discussion. Safety measures are re-interpreted and re-defined through negotiations between managers and workers. Field managers, who are faced with employee and union pressure, have had to manage many solicitations and negotiations. “It’s not just a matter of following guidelines for social distancing. It’s more a question of how you identify all existing risks and invent work methods that minimize these risks.” Many “invisible” jobs in the field such as cleaning or maintenance have become viable activities.

Adapting responses on a case by case basis

This crisis highlights a company’s ability to adapt. Certain necessary changes such as cost reduction measures have important economic impacts and can mean canceling agreements with suppliers, who are often part of the process for new product development. While industrial activity is being maintained, there is much uncertainty as to how demand will evolve over the next couple of months. This study will be followed up by Axel Genevois in order to highlight the various differences and similarities in sectors such as logistics. “The first lesson from this crisis is the importance of resilience for production organizations and their ability to integrate new constraints and deal with uncertainty. But this crisis also gives new meaning to the importance of social dialogue thanks to a shared risk and its impact on workplace activities. The crisis highlights the interdependent chains that link all economic activities. This understanding will be essential to deal with future threats such as climate change and the scarcity of resources,” concludes the researcher in a recent article****.

* PACTE, social science laboratory and mixed research unit (CNRS, Université Grenoble Alpes and Sciences Po Grenoble)
** This study is part of a research project led by Cécile Ciolez, a lecturer at Grenoble INP – Génie industriel, UGA and researcher at PACTE. The project focuses on the resilience of various organizations when dealing with the current epidemic.

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