LJK

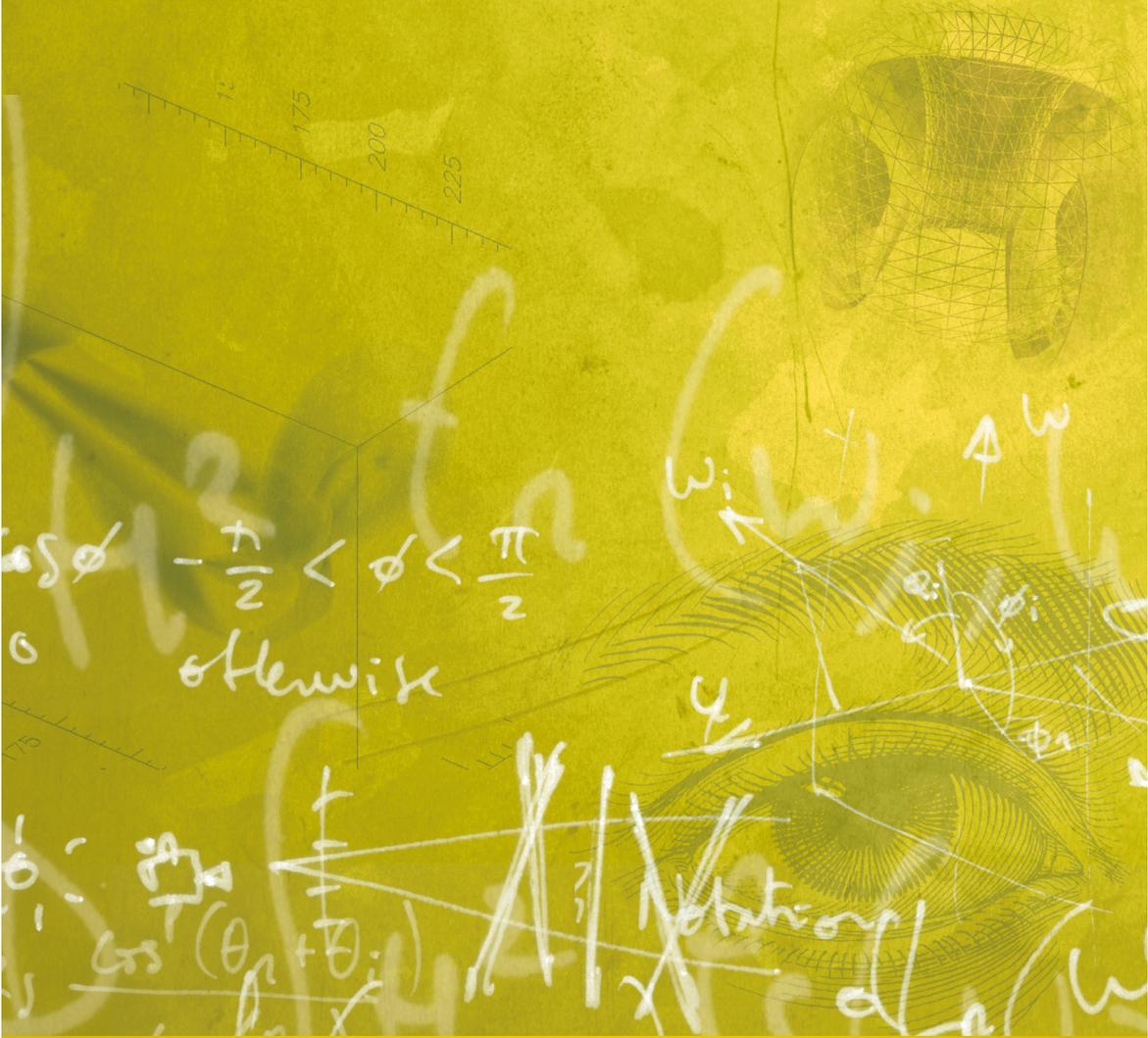**LABORATOIRE JEAN KUNTZMANN**

MATHÉMATIQUES APPLIQUÉES – INFORMATIQUE

HIGHLIGHTS

FAITS MARQUANTS

2023
— EDITION —

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TRIPOP Vincent Acary		**THOTH** Julien Mairal

December 2022

FOREWORD

The synergy between computer science and applied mathematics is the essence of the Jean Kuntzmann Laboratory, a joint research unit of Grenoble Alpes University, CNRS, Grenoble INP (Institute of Engineering) and Inria. This multidisciplinarity makes it a rich structure, both humanly and scientifically. In a spirit of conviviality and creative enthusiasm, the success of our teams is the result of a joint investment, favouring exchanges, ethics and scientific rigour.

The unit thus brings together more than 250 people particularly mindful to gender equality, sustainable development and quality of business life. We are organised with four support and three scientific departments, the latter comprising seventeen research teams.

Our research focuses on analysis, on scientific and high-performance computing, on modelling, on exact and symbolic computation, on cybersecurity, on inverse problems, statistics and probability, on machine learning, signal and image processing, on data mining, optimisation, applied geometry, graphic computing or computer vision.

The versatility of the fields of application of the projects is large, ranging from mechanics to biology, or from image and cryptology, to economics and finance. We are happy to present in this 2023 edition of the highlights of the Laboratoire a compendium of our past two years of research that illustrates the pursuit of a common vision.

Among them, we emphasise here many scientific developments, that are at the heart of our activities, as well as portraits of three of our colleagues.

Our results range from theoretical studies to computational modelling and simulation. We point out for instance improvements of the representation of ocean-atmosphere interactions in climate models, an analysis of bias and acceptability in recruitment, a solution for protein structure prediction problem finally solved, efficient high-order masking protections for arithmetic circuits, as well as a novel modelling of the evolution of addiction, with the behavior of online gamblers.

We also have developed fast marching schemes in anisotropic medium, models for energy return on investment and the feasibility of an energy transition, an algorithm of optimal complexity for the characteristic polynomial of a matrix, or an analysis of the impact of anthropogenic activity on narwhals.

This is illustrated also by several industrial collaborations, start-ups and computing platforms for pooling covid 19, for the knowledge transfer of artificial neural networks, for the visualisation of Isadora Duncan's movement qualities, or for the computer assisted creation of mountain panorama maps.

Overall, a number of prestigious prizes were awarded to members of the LJK and we organized no less than seventeen multidisciplinary and international events.

Jean-Guillaume Dumas

PORTRAITS

Emmanuelle Crépeau
› EDP team

Emmanuelle Crépeau is an assistant professor in the PDEs team of the LJK and head of the AMAC department since 2021.

She entered the École Normale Supérieure de Cachan in 1996 and obtained her PhD in 2002 at the University of Paris Orsay. After a post-doc at Inria Rocquencourt, she was a lecturer at the University of Versailles-St Quentin en Yvelines from 2004 to 2019. In 2019, she obtained her Habilitation à Diriger des Recherches and moved to Grenoble.

Her research is devoted to controllability problems of partial differential equations and to stabilisation and inverse problems. One of her most famous results concerns the controllability of the Korteweg-de Vries equation. She succeeded in proving that even if the problem linearised around the null solution is not controllable for certain lengths of the spatial domain, the nonlinear problem is controllable. This result is very interesting because usually the controllability of nonlinear problems is obtained with the controllability of the linear problem and a fixed point argument. This is the first result of this type in the control community. It uses asymptotic development techniques and a fine knowledge of the spaces "missed" by the linearised problem.

In recent years, she has been interested in control, stabilisation and inverse problems for PDEs evolving on networks. These domains can be networks like stars or trees for example and the conditions at the internal nodes are very important and lead to many difficulties. This theme is one of those that will be developed in the MathAmSud project that she coordinates. This project gathers 20 researchers from Brazil, Chile and France and allows exchanges between researchers from these countries.

In parallel to her research activities, she enjoys teaching students from L1 to Master level. She is also involved in the Laboratory, as co-responsible of the PDEs seminar, but also as a referent for the PhD students of the laboratory.

Franck Lutzeler
› DAO team

Franck Lutzeler is an Assistant Professor (Maitre de conférence HDR) in applied mathematics at Univ. Grenoble Alpes and member of LJK. His research topics are centred around mathematical optimisation and statistical learning. More specifically, he has recently been interested in the theory of distributionally robust optimisation, the numerical exploitation of nonsmooth substructure appearing in regularised learning problems, or the development of optimisation methods for multi-agent systems.

He obtained his Ph.D. degree in 2013 from the Telecom Paris, with a thesis focusing on estimation and optimisation over graphs. He was a post-doctoral researcher at Supélec and at Université Catholique de Louvain before joining the LJK in 2015. In 2019, he was awarded an ANR JCJC grant for his research project on the numerical exploitation of smooth substructures in nonsmooth optimisation. He defended his Habilitation à Diriger des Recherches in 2021.

A particularity of Franck's research is the combination of mathematical programming theory with numerical optimisation to tackle a variety of problems arising from statistics or machine learning. For instance, in machine learning, a prior structure can be imposed on the model by adding a nonsmooth regularisation. It can be shown that appropriate optimisation methods can recover the structure of the problem's optimum in finite time, before convergence. This can in turn be exploited to efficiently accelerate numerical methods (which was the centre of Franck's ANR project). Franck pays a special attention to develop and distribute the code associated with the proposed methods and illustrations.

Recently, Franck has started working on distributionally robust optimisation. This project is motivated by statistical learning problems where the data distribution can differ between training and application due to a lack of available examples, biases in the collection, or simply distribution shifts. One remedy is to train a model on the worst distribution for the objective that is close to the data in Wasserstein distance. This approach gives some robustness around the collected data (to account for the changes mentioned above) that can be quantified theoretically. However, the resulting optimisation problem is often intractable. A recent contribution of Franck was thus to propose a regularisation of this problem, inspired by the entropic regularisation in optimal transport, that leads to numerically computable objectives.

Caroline Bligny
› SCALDE team

Caroline graduated from INSA Lyon and has a DEA in cognitive sciences. After a career in the private sector, she joined the LJK and the CNRS in 2011 as an engineer, to work on 3D data visualisation as well as on the databases and information systems of MaiMoSiNE (House of modelling and simulation, nanoscience and environment).

Thanks to her cross-disciplinary skills, she collaborates with colleagues in all topics of the LJK and plays a central role in the laboratory data management. She also works on the laboratories in-house HR management system, the SILOSE project (Workforce Monitoring Tools).

Caroline is part of the SCALDE team (the LJK Scientific Computation and Development Department). She is regularly involved in multidisciplinary projects concerning data processing and the setting up of specialised databases with external partners. For example, she is currently involved in a project aiming at setting up a cross-referenced database of court decisions concerning electoral litigation. This data is cross-referenced with election results to perform statistical computations. This project is conducted in collaboration with the CRJ (Legal Research Centre of the UGA). In this framework, she supervises interns from the MIASHS masters.

Previously, as part of the LabCom Innovalie between the University Grenoble Alpes (UGA) and the professional rugby club of Grenoble (FCG), she developed a software that computes the Force-Speed parameters of a sportsman via the real-time analysis of sprint radar data. The software is currently being used by the FCG to improve the training of players.

Caroline is also involved in the training of doctoral students of all disciplines on the aspects of data formats and visualisation, and also gives database courses at the IUT2. She was promoted to research engineer in 2022.

Finally, in 2021, Caroline received a collective crystal medal from the CNRS for her involvement in a data processing project on Covid-19. The team of engineers who received the award developed a dynamic mapping of clinical trials related to the Covid-19 pandemic. Over a short period of time and in a strict lockdown period, this team, which came from 7 different research structures and in collaboration with researchers, was able to federate complementary expertise to contribute to the development of effective solutions. This work provided solutions that could be generalised to other areas of the health sector.

The newcomers

Michael N. Arbel
THOTH team / INRIA

Jean-Yves Courtonne
STEEP / INRIA

Christophe Dutang
› ASAR team / G INP

Brunot Grenet
› CAS^{3}C^3 team / UGA

Aristide Irié
› IT resources /CNRS

Guillaume Mandil
› STEEP team / UGA

Mathieu Mangeot
› STEEP team / Université de Savoie

Pedro LC Rodrigues
› STEEP team / INRIA

Victor Romero
› ELAN team / INRIA

Salem Said
› DAO team / CNRS

Martin Schreiber
› AIRSEA team / UGA

MULTI-DISCIPLINARY INTERACTIONS

COCOA project: improving the representation of ocean-atmosphere interactions in climate models
› AIRSEA team

Schematic view of a 3-dimensional mesh of the atmosphere. © Institut Pierre-Simon Laplace.

The ocean and the atmosphere continuously exchange huge quantities of water (evaporation, precipitation), heat and momentum (wind, current), and these exchanges play a key role in the climate system. However the physical processes involved are very complex, which makes their modelling, and thus the precise evaluation of these fluxes within the models, particularly difficult. Moreover, simulating the climate requires very heavy computational resources, which do not currently allow a representation as fine as one would like: the horizontal resolution of climate models is only of the order of a hundred kilometres, while ocean-atmosphere interactions (OA) are also significant at much finer scales. Improving the representation of these interactions is therefore a major challenge for climate models.

The COCOA ANR project (2017-2021) has focused on this scientific question, both from a physical point of view (by working on the modelling and impact of sub-grid and high-frequency phenomena not represented until now), and from a mathematical point of view (by seeking to improve the coherence with which the models interact). It has brought together a consortium of applied mathematicians, atmospheric scientists, oceanographers and climatologists, which has enabled work ranging from fine physical analyses of processes at the air-sea interface to development of numerical methods and large-scale numerical simulations with the two French climate models (IPSL-CM and CNRM-CM).
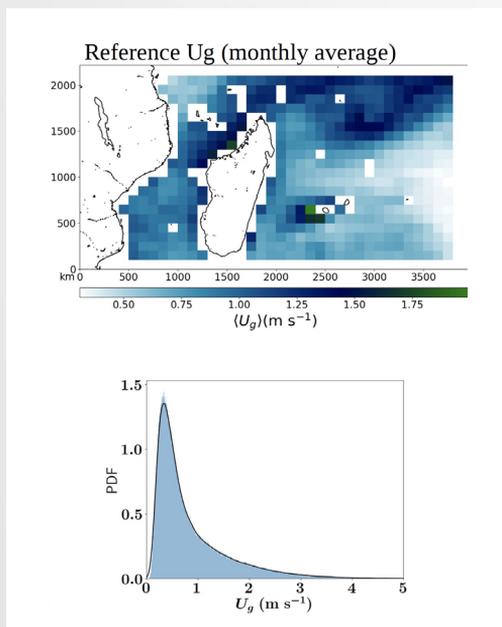

Monthly-averaged map of wind gust in the southwestern Indian ocean, and corresponding probability density function. © CNRM Toulouse.

From a physical point of view, the project demonstrated the importance of taking into account small-scale and/or high-frequency phenomena (such as wind gusts or diurnal heating at the ocean surface) in the OA exchanges, even on a large scale. Several numerical tools have been developed, which will be reused in future studies: a 1-D coupled OA model; a LES coupled OA model that will allow the fine study of air-sea interactions and the development of parameterisations simulating their impact on a larger scale; a test case for which real observations are available... The importance of the synchronisation during the coupling has also been highlighted, and a new algorithm ensuring it has been developed. Moreover a mathematical framework adapted to the modelling of these OA interactions has been formalised.

The results of the COCOA project have been disseminated through more than 30 articles and book chapters published in international journals of meteorology, climatology or applied mathematics, and 50 presentations in national and international conferences.
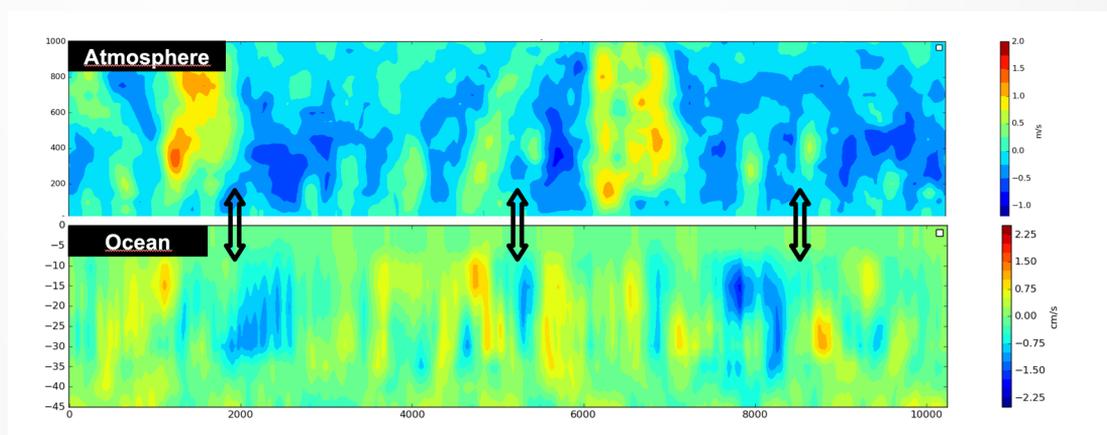
Vertical section (x-z) at a constant latitude of the vertical velocity field,
on both sides of the ocean-atmosphere interface, obtained by a very high resolution (LES) coupled simulation.
The section is 10 km long, 1000 m high in the atmosphere and 45 m deep in the ocean. © J.-L. Redelsperger, LOPS Brest

MULTI-DISCIPLINARY INTERACTIONS

Protein structure prediction problem finally solved
› DAO team

In the last couple of years we witnessed a revolution in the field of protein structure prediction, with protein models reaching unprecedented levels of near-experimental accuracy [1,2]. The 50-years-old problem of determining how a single protein folds in three dimensions (3D) seems to be finally resolved. Indeed, biology hides many puzzles that seem to be very difficult to solve by using pure physics approaches. For example, the question on how a protein sequence adopts its 3D shape arose already more than a half-century ago.

In the early 1970s, Christian B. Anfinsen, the Nobel Prize Laureate, postulated that at least for a small globular protein at its physiological conditions, its native structure is fully determined by the protein's amino acid sequence [3]. Around the same time, in 1969, Cyrus Levinthal conducted the famous thought experiment, now known as the Levinthal paradox [4]. He noted that, if a protein were to attain its correctly folded configuration by sequentially sampling all the possible conformations, it would require a time much longer than the age of universe. Yet, most small proteins fold spontaneously on a microsecond—millisecond time scale.

These findings motivated the research community to study computational approaches for protein folding and structure prediction, and later led to the establishment of the blind CASP (Critical Assessment of protein Structure Prediction) community challenge and a finally resulted in a discovery of a practical solution of the protein structure prediction problem using deep-learning techniques [1,2].

Our team was the first to apply 3D convolutional neural networks to protein structures [5-7]. Later, we built the first convolutional neural network on 3D Voronoi tessellations [8] and extended it for orientation-dependent graph kernels [9]. We have also extended a classical 2D/3D convolution to a roto-translational 6D convolution [10]. We were also the first to demonstrate that coarse-grained potentials can be efficiently used for virtual drug screening [11].

[1] **Highly accurate protein structure prediction with AlphaFold**, J. Jumper et al. Nature, 596(7873), 583-589, 2021.

[2] **Protein sequence-to-structure learning: Is this the end(-to-end revolution)?** E. Laine et al. PROTEINS, 89(12), 1770-1786, 2021.

[3] **Principles that govern the folding of protein chains**, C. B. Anfinsen. Science, 181(4096), 223-230, 1973.

[4] **How to Fold Graciously, in Mössbauer Spectroscopy in Biological Systems: Proceedings of a meeting held at Allerton House**, C. Levinthal. Monticello, Illinois. P. Debrunner (ed.), JCM Tsibris, and E. Münck, University of Illinois Press, 1969.

[5] **Deep convolutional networks for quality assessment of protein folds**, G. Derevyanko et al. Bioinformatics, 34(23), 4046-4053, 2018.

[6] **Protein model quality assessment using 3D oriented convolutional neural networks**, G. Pages et al. Bioinformatics, 35(18), 3313-331, 2019.

[7] **DeepSymmetry: using 3D convolutional networks for identification of tandem repeats and internal symmetries in protein structures**, G. Pages and S. Grudinin. Bioinformatics, 35(24), 5113-5120, 2019.

[8] **VoroCNN: deep convolutional neural network built on 3D Voronoi tessellation of protein structures**, I. Igashov, K. Olechnovič et al. Bioinformatics, 2021.

[9] **Spherical convolutions on molecular graphs for protein model quality assessment**, I. Igashov, N. Pavlichenko and S. Grudinin. Mach. Learn.: Sci. Technol. 2021.

[10] **6DCNN with roto-translational convolution filters for volumetric data processing**, D. Zhemchuzhnikov, I. Igashov, and S. Grudinin. Proceedings of the 36th AAAI Conference on Artificial Intelligence, 2022.

[11] **KORP-PL: a coarse-grained knowledge-based scoring function for protein-ligand interactions**, M.Kadukova et al. Bioinformatics, 37(7), 943-950, 2021.
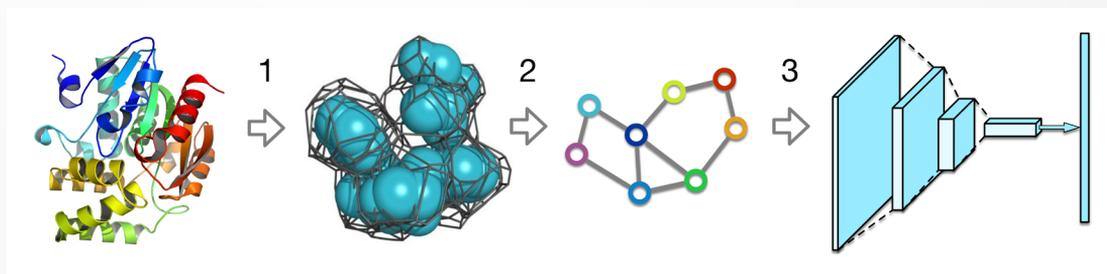
Schematic representation of the VoroCNN quality assessment method. Firstly, a Voronoi tessellation of a 3D-model is computed with Voronota. Then, based on Voronoi 3D tessellation, a graph is built. Finally, a graph neural network predicts local CAD-scores of all residues in the initial model.

MULTI-DISCIPLINARY INTERACTIONS

IAB@R project: Artificial Intelligence, Bias and Acceptability in Recruitment
› SVH team
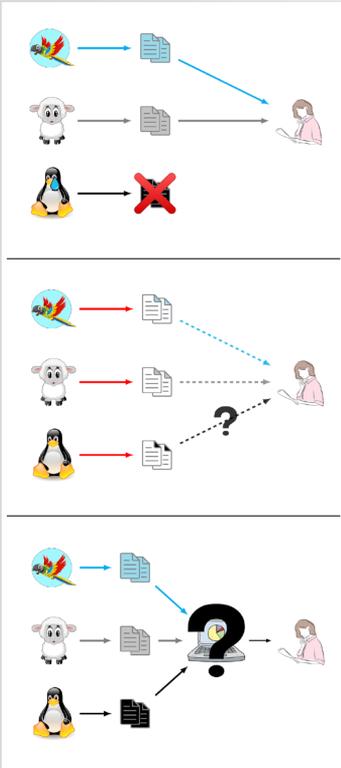
Project schematic.

Recent advances in the field of artificial intelligence have also seen an explosion in solutions for automatic candidate recommendations via semantic CV searches[1], solutions for analysing verbal and non-verbal signals during interviews[2], and tools for predicting the ability of candidates to get along with a team and work effectively[3]. All of these solutions promise more efficient recruitment and, above all, freedom from bias and discrimination.

However, while bias and discrimination are inherent risks in any human recruitment decision, the particularities that characterise AI technologies, in terms of opacity, complexity, partially autonomous behaviour, do not provide guarantees to reduce these biases, and it is even possible to think that AI can generate other types of bias [1]. For example, an algorithm trained to make decisions on the basis of biased social data reproduces these biases, or even amplifies them, and creates strong discriminations based on criteria such as gender, age, origin of individuals (see [2]).

In this context, the IAB@R project co-sponsored by the LJK and CERAG* aims to question the validity and impacts of AI tools applied to recruitment. It must be noted that studies are rare while the demand for empirical data is high [5] and that the stakes are high and particularly sensitive, especially in the context of promoting diversity and the fight against discrimination. This fight corresponds not only to an ethical imperative but also to a legal obligation in terms of the explicability of decisions taken on the basis of algorithmic recommendations (the law specifies that recruiters must be able to justify their choices if necessary).
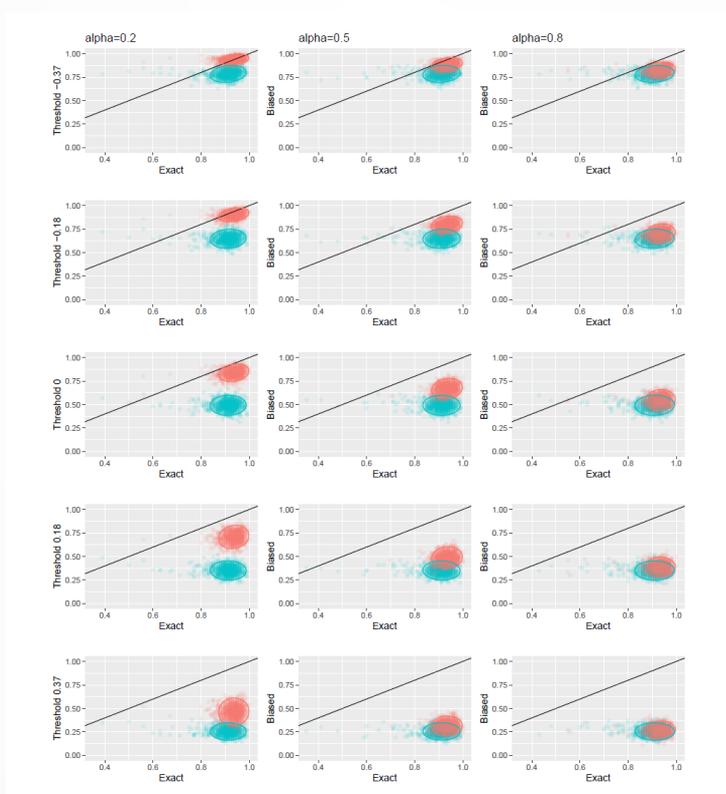
The first results [3, 4] attempt to show that recruiters tend to follow the advice of the algorithms even if they disagree. However, the first tests carried out using classic algorithms on toy examples show that the more complex the algorithm, the more it will perpetuate or even amplify the biases. Moreover, the results show that the anonymization of CVs has only a weak impact on this phenomenon and is even completely useless in the case of very strongly biased learning bases if there is even the slightest correlation between a discriminating (unobserved) variable and a variable appearing on the anonymous CV (for example, the fact of belonging to an association that could have a link with the variable deemed to be discriminating).

The next objective of this project is to engage in partnerships to encourage companies to reflect on their codes or even to open them up partially to allow for a limitation of bias in future recruitments.

1. https://www.avature.net/fr/
2. https://cryfe.swiss/#cryfe
3. https://www.assessfirst.com/fr/solutions/recrutement/

Representation of the average errors in having correctly selected the best record of each interview from the censored data versus the uncensored data for the multilayer perceptron. Red color corresponds to full data (X,Y,Z) and blue color to anonymized data (X,Z) for 1000 interviews; ellipses correspond to 95% areas. The rows correspond to the different discrimination thresholds and the columns to the dependence between the discriminatory variables and the auxiliary variables kept for the discriminations. The black line corresponds to the line of equation y=x.

*CERAG: Centre for Applied Management Studies and Research

[1] **L'intelligence artificielle au service de la lutte contre les discriminations dans le recrutement: nouvelles promesses et nouveaux risques**, A. Lacroux and C. Martin-Lacroux. Management Avenir, 122, 121–142, 2021.

[2] **Détecter, évaluer les risques des impacts discriminatoires des algorithmes d'IA**, P. Besse. 2020.

[3] **Should I Trust the Artificial Intelligence to Recruit? Recruiters' Perceptions and Behavior When Faced With Algorithm-Based Recommendation Systems During Resume Screening**, A. Lacroux and C. Martin-Lacroux. Frontiers in Psychology, 13, 895997, 2022.
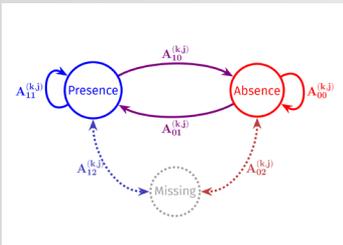
[4] **Croire ou ne pas croire les algorithmes… telle est la question ? Perceptions et comportement des recruteurs face aux algorithmes lors de la présélection de CV**, A. Lacroux, C. Martin-Lacroux, and V. Brault. 33e Congrès de l'AGRH, October 2022, Brest.

[5] **Donner un sens à l'intelligence artificielle: pour une stratégie nationale et européenne**, C. Villani et al. Conseil national du numérique, 2018.

MULTI-DISCIPLINARY INTERACTIONS

Modelling the evolution of addiction criteria and the behavior of online gamblers
› SVH team

Schematic modelling of DSM V criteria status changes to analyse criteria evolution.

Representation of the behaviours of four of the eight groups created by our modelling (in rows) according to each of the nine DSM V criteria (in columns, only two last criteria visible here): the orange dotted line represents the evolution of the probability of having each criterion within the group and the points are the observations. The histogram on the right represents the distribution of the end of follow-up times of the subjects in the group and the percentage of participants present in each group (in counts, we have 52, 130 and 35).

«Gambling carries risks: debt, isolation, dependence».

Gambling and gaming organisations have to put this sentence on their sites or when they advertise since France in 2010 adopted the law to regulate online gambling and open up the market to competition [1]. However, during the last football World Cup, 615 million euros were bet in France, i.e. 168% of what was bet in 2018 and 146% in 2021 during the Euro. Similarly, according to Santé Publique France, the number of excessive gamblers doubled between 2014 and 2019 [2].

Pathological gambling is an addictive disorder characterised by persistent and recurrent problem gambling behaviour, resulting in clinically significant impairment or distress. Common diagnostic criteria stem from the Diagnostic and Statistical manual of Mental disorders (DSM): a person can be determined to be suffering from pathological gambling if he or she has at least 4 of the 9 possible criteria, with the level of severity being determined by the number of criteria present. Hence, two people can be diagnosed with the same disorder based on completely different criteria, making the clinic of the disorder very heterogeneous. Thus, some criteria may be more readily present at higher levels of severity, and some authors have criticised the presumed equal weight of different criteria in establishing the diagnosis [3]. Moreover, this disorder is characterised by its nonlinear evolution (return to controlled practice, relapse...), but the dynamics of the evolution of the different criteria over time have been little studied.

A collaboration with the INSERM SPHERE team in Nantes and Tours aims at modelling the evolution of addiction criteria and the behaviour of online gamblers. The aim is to propose a more personalised follow-up of pathological or non-pathological gamblers in order to better support them and/or prevent a possible switch from non-pathological to pathological gambling.

The first results dealing with the modelling based on unsupervised classification of gamblers (Figure 2) seem to show typical profiles. For example, the criterion on lying seems to be strongly correlated with the criterion on borrowing, which would suggest that their uses are redundant. On the other hand, the criterion on dysphoria (state of painful discomfort) seems independent of the others. The results may allow the DSM recommendations to evolve.

A model combining unsupervised classification and segmentation is being studied on data from the Française des Jeux and a platform in Sweden. The aim is to study the impact of successive confinements on the gambling behaviour of (non)pathological gamblers.

[1] JORF n°0131, June 9th 2010.

[2] *Jeux d'argent et de hasard dans le baromètre de Santé publique France 2019: description des joueurs, des pratiques et des problèmes en population adulte*, Santé Publique France, accessed March 26th 2023.

[3] *DSM-5 criteria for gambling disorder: Underlying structure and applicability to specific groups of gamblers*, P. Sleczka et al. J. Behav. Addict, 4(4), 226–235, 2015.

(Re-)Framing Virtual Reality

› ANIMA team

We address the problem of translating the rich vocabulary of cinematographic shots elaborated in classic films for use in virtual reality. Using a classic scene from Alfred Hitchcock's «North by Northwest», we describe a series of artistic experiments attempting to enter «inside the movie» in various conditions and report on the challenges facing the film director in this task. For the case of room-scale virtual reality, we suggest that the absence of the visual frame of the screen can be usefully replaced by the spatial frame of the physical room where the experience takes place. This «re-framing» opens new directions for creative film directing in virtual reality.

(Re-)Framing Virtual Reality, R. Sagot-Duvauroux, F. Garnier and R. Ronfard. *Eurographics workshop on Intelligent Cinematography and Editing, 2022.*

Equirectangular 360° view of our version of Alfred Hitchcock's «North by Northwest» in virtual reality. In the absence of a visual frame, we can impose a spatial frame around the immersant, with its own affordances for action, which gives rise to a new vocabulary of shot types.

Visualising Isadora Duncan's movements qualities

› ANIMA team

We present a new abstract representation of choreographic motion that conveys the movement quality of fluidity that is central to the style of modern dance pioneer Isadora Duncan. We designed our model through a collaboration with an expert Duncanian dancer, using five flexible ribbons joining at the solar plexus and animated it from motion capture data using a tailored optimisation-based algorithm. We display our model in a Hololens headset and provide features that allow to visualise and manipulate it in order to understand and learn Duncan's choreographic style. Through a series of workshops, we explored our system with professional dancers and were able to observe how it provides them with an immersive experience of a novel visualisation of Duncan movement qualities in a way that was not possible with traditional human-like or skeleton-based representations.

Workshop participants learning the Moment Musical dance with our expert Duncanian Dancer. © 2022 Association for Computing Machinery.
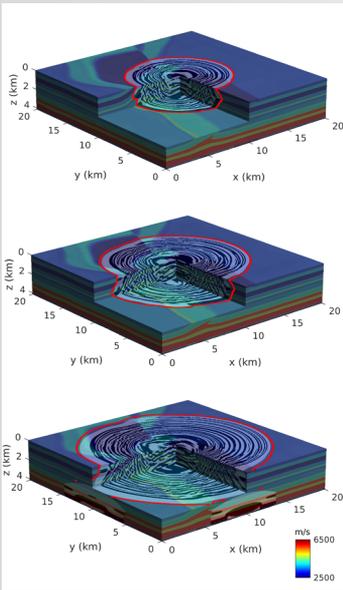
Visualizing Isadora Duncan's movements qualities, M. Vialle, S. F. Alaoui, M. Skouras, V. Vilvanathan, E. Schwartz and R. Ronfard. In C&C 2022 - 14th ACM conference on Creativity & Cognition. Venice, Italy, June 2022, pp. 196–207, 2022.

SCIENTIFIC RESULTS OF THE TEAMS

Fast marching schemes for the solution of the eikonal equation in anisotropic media
› EDP team

Comparison of the solutions of the eikonal equation (red curve) and of the elastic wave equation (in black and white), at times: t=1.5 s, t=2 s, t=2.5 s superimposed to the background velocity for pressure waves for a vertical force source located at the center.

Computing the time seismic waves take to travel within the Earth is crucial in many fields of applications of seismology: for instance to locate hypocenters of earthquakes, or to infer information about the Earth's structure itself through an estimation of the seismic wave velocities by tomography. From a mathematical standpoint, computing these propagation times is equivalent to approximate the solution of a particular equation named eikonal equation.

Eikonal equations describe the propagation of waves as rays propagating in a given medium. In simple (homogeneous and isotropic) media, rays propagate as straight lines. In the Earth's crust, rays propagate in a much more complicated way: they bend and distort.

One particular difficulty is when the wave propagation velocity depends on the orientation of the waves. Such kind of medium is referred to as an anisotropic medium. Numerical approximation schemes known as fast marching schemes, developed to compute approximate solution to eikonal equations, usually work well for isotropic media but might converge slowly or even diverge for anisotropic media.

In the PhD work of François Desquilbet, together with Jean-Marie Mirebeau (CNRS, Centre Borelli, ENS Paris-Saclay), we have developed two new fast marching schemes for solving the eikonal equation in anisotropic media which are both efficient and accurate.

The first is based on a integer decomposition of symmetric positive matrices which makes it possible to develop stable finite difference schemes adapted for any kind of elastic anisotropy.

The second is focused on a particular type of anisotropy, named Transverse Tilted Isotropy (TTI).

The underling metric associated with such anisotropy is approximated by an envelope of elliptic metrics for which efficient fast marching schemes already exist. We show that the TTI solution can be computed as a concave/convex envelope of the solution obtained for these elliptic metrics.

# When point processes meet high dimension

› SVH team

Random events collected in time, space (or both), such as locations of trees in a forest, disease cases, impacts of lightning strikes, earthquakes occurrences, form point patterns. Point processes are stochastic models able to locally describe the occurrence of an event at a specific location (called intensity function) and/or to model the dependence between two or more random events. When covariates are available (e.g. topographic and environmental data in forestry applications), it is natural to model parametrically the log-intensity through a linear function of the covariates. When the number of covariates is large compared to the observed (random) number of events, the statistical challenge is then to select the covariates that really explain the point process intensity.

For that purpose, the lasso penalisation and the Dantzig selector (popularised by Candès and Tao) and more generally regularisation techniques are well-known procedures that have been widely used on standard models such as generalised linear models with independent observations. Likelihood functions are usually intractable for spatial point processes. In [1], we consider regularised versions (using convex and non-convex penalty functions) of several composite likelihoods (since likelihoods are usually intractable in this domain) to estimate the intensity of a spatial point process.

In [2], we extend the asymptotic framework and compare the adaptive lasso with an adaptive version of the Dantzig selector. The main statistical challenges, common to these two works, are to propose a fast, robust and easily reproducible implementation of proposed procedures and to obtain theoretical guarantees for a large class of dependent point processes and for different asymptotic regimes. In particular, in [2], we prove consistency and oracle properties (that is the guarantee that the procedure correctly sets to zero parameters estimates from non-informative covariates) under an infill/increasing asymptotic framework where, in addition, the number of informative and non-informative covariates may increase with the mean number of points.

In collaboration with Amélie Artis (PACTE lab), we are now working on an application of this work to explain the spatial distributions of cooperative and lucrative banks in France with respect to local socio-economic data.
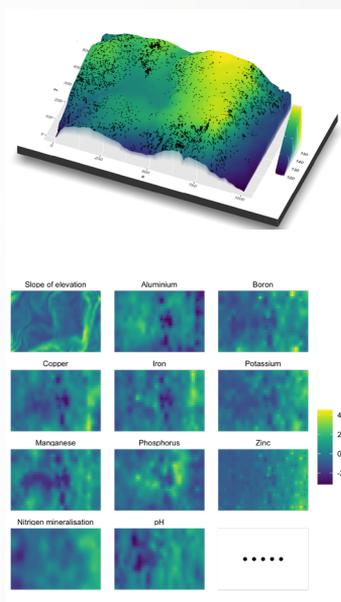
Top: A point pattern giving the locations of 3605 trees in a tropical rain forest; Bottom: Some of spatial (topographic and soil nutrients) covariates observed on the same observation domain. Our works consist in selecting the most informative covariates (and combinations of them) to explain the arrangement of trees.

[1] **Convex and non-convex regularization methods for spatial point processes intensity estimation**, A. Choiruddin, J.-F. Coeurjolly, and F. Letué. Electronic Journal of Statistics, 12, 1210–1255, 2018.
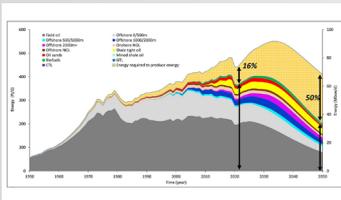
[2] **Adaptive lasso and Dantzig selector for spatial point processes intensity estimation**, A. Choiruddin, J.-F. Coeurjolly, and F. Letué. Bernoulli, 29(3), 1849–1876, 2023.

SCIENTIFIC RESULTS OF THE TEAMS

Modelling Energy Return on Investment and the feasibility of an energy transition
› STEEP team

Historical (1950–2020) and projected (2020–2050) net energy of fossil liquids production, by category. The difference between net and gross energy is shown in orange, with numbers given for 2021-2022 (end of the COVID drop in energy use) and 2050.

Energy Return on Investment (EROI) issues have long been studied in the literature. The STEEP team has undertaken an extensive reanalysis leading to two pioneering papers that present a comprehensive view of the problem for all fossil liquids [1] and gases [2]. Coal has not been analysed due to its still high EROI.

The main result is that the world is facing an increase of the energy needed to extract fossil liquids in the coming years (a decade at most). By 2030, 25% of the extracted oil energy will be needed for its extraction, a figure climbing to 50% by 2050, mostly because we will be running out of the most easily accessible resources; this amplifies the underlying trend of saturation of fossil fuel extraction in terms of gross energy produced [3]. An extensive sensitivity analysis has been conducted, ensuring the robustness of the results, that begin to attract a growing attention even beyond the community of energy experts.

This issue bears on annual flows, not stocks, and leads to inescapable tensions on oil uses, in particular in transports, where oil represents more than 90% of all energy sources. This will definitely lead to increases in oil prices; this conclusion is reinforced by the recent announcement by Saudi Arabia (the pivotal oil producer worldwide) of its maximum of production by 2027. Supply will most likely be shrinking faster than demand, as all fossil fuel projections are customarily cast in gross instead of net figures.

Our contributions lie in 1) the proper formulation of the problem, which had not been adequately addressed by the scientific literature, 2) the practical deployment of a robust and reliable methodology based on an exhaustive and thorough analysis of the scientific literature; and finally 3) the analysis of the results and of the subsequent issues.

This leads naturally to the question of the feasibility of an energy transition, which is the subject of an ongoing PhD thesis. Can an all-electric transition be achieved in time? Our preliminary analysis indicates that the technological inertia has been underestimated in existing energy transition models. This analysis is based on an integrated modelling of the energy / macroeconomics / macrofinance nexus, which also serves to understand systemic risks induced by the strong interdependencies between these sectors.

[1] *Peak oil and the low-carbon energy transition: A net-energy perspective,* L. Delannoy, P.-Y. Longaretti, D.J. Murphy, and E. Prados. Applied Energy, 304, 117843, 2021.

[2] *Assessing Global Long-Term EROI of Gas: A Net-Energy Perspective on the Energy Transition,* L. Delannoy, P.-Y. Longaretti, D.J. Murphy, and E. Prados. Energies, 14(16), 5112, 2021.

[3] *EROI-de plus en plus d'énergie pour avoir du pétrole, et alors ? PlanB* (Interview), 2021.

Computing the characteristic polynomial of a matrix in optimal complexity

› CAS³C³ team

Computational linear algebra is a foundational tool of scientific computing in both numeric and symbolic computations. Numerous applications such as robotics, biology, experimental mathematics or cryptography, motivate research to improve its computational complexities and develop high-performance software implementations.

While most linear algebra problems could be solved in cubic time in the matrix dimension, a breakthrough happened in 1969, when Strassen introduced recursive algorithms for multiplying and inverting matrices in sub-cubic time. The product of matrices has since then been repeatedly improved, and many algorithmic reductions have drawn connections between the various problems and offered a better understanding of their respective difficulties. Consequently, most operations can be computed with the same cost as a product of matrices, a cost proven to be optimal for several of them. Strassen's method as well as reductions have also become central in state-of-the-art software libraries.

The computation of the characteristic polynomial of a matrix reveals crucial information in its invariants. It is for example, a bottleneck when solving multivariate polynomial systems. In the early 1980s, it was the last basic matrix operation that had cubic complexity and did not enjoy an efficient reduction to a matrix product. In 1985, Keller-Gehrig gave such a reduction, but with a logarithmic factor away from the optimal. Since then, the only algorithms that avoided this extra cost were either based on genericity assumptions or on probabilistic algorithms with constraints on the field of the matrix' coefficients.

Our new algorithm is deterministic and runs in same time as a matrix product, a lower bound for the problem, with no requirement on the field. To do so, the algorithm relies on fast polynomial and matrix arithmetic, exploiting very recent results on the subject and exploring a new path in the dimension/degree trade-offs used so far. The result applies more generally to the computation of determinants of a large class of polynomial matrices, called «reduced matrices». In addition to the optimal complexity, an implementation of this algorithm proves to have better performances than the state of the art for this task, especially on small finite fields.

Vincent Neiger, LIP6 (CNRS/Sorbonne University) and Clément Pernet, LJK (CNRS/Grenoble INP/Université Grenoble Alpes) have received a Best Paper Award from the Journal of Complexity for this research.

SCIENTIFIC RESULTS OF THE TEAMS

Impact of anthropogenic activity on narwhals

› SVH team
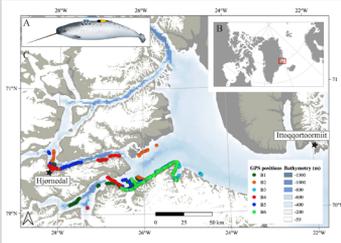
Study area with tracks of 6 tagged narwhals (colored circles), (A) narwhals were instrumented with GPS transmitters, (B) Scoresby Sound fjord in East Greenland.

Anthropogenic activities are increasing in the Arctic due to climate-induced decreases in sea ice cover. This poses a threat to animal species with high seasonal site fidelity, such as the narwhal Monodon monoceros.

In this controlled sound exposure study, sixteen narwhals were captured alive and equipped with on-board satellite tags providing data on their movements and behaviour, and exposed simultaneously to ship noise and airgun pulses, mimicking the noise of a mining industry. The experiment was divided into trials with exposure to airgun and ship noise, intermediate trials with only ship noise, and pre- and post-exposure periods. The trials and intermediate trials averaged about 4 hours per individual.

We analysed narwhal noise emission data by Poisson processes with a non-homogeneous random intensity function in time, including non-linear covariates. We also modelled the whales' distance to shore by Markov models.

All narwhals responded to sound exposure by reducing their humming rate, where the response depended on the distance to the vessel. The humming rate was halved at 12 km from the ship, and the whales stopped feeding at 7-8 km. The effects of exposure could be detected at distances greater than 40 km from the ship. At only a few kilometres from the ship, the received high-frequency weighted sound exposure levels of the cetaceans were below background noise, indicating the extreme sensitivity of narwhals to sound disturbance and demonstrating their ability to detect signals embedded in the background noise.

Effect of sound exposure on the buzzing rate as a function of distance to the sound source. The curved black line indicates the population-level estimate of the effect and the horizontal black line indicates the undisturbed buzzing rate on a population level. Individual estimated and the corresponding undisturbed buzzing rates are given in different colours.
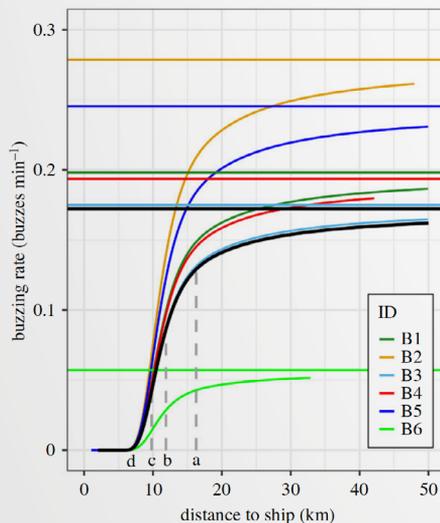
The whales had an avoidance response by altering their trajectory when the boat was present. This avoidance response was shown to be significant even when the boat was more than 20 km away. For example, they increased their horizontal speed by 30% and they had a propensity to move towards the shore, this propensity increasing when the boat was close.

Narwhal responses to sustained disturbance can have many consequences at both the individual and population levels. The observed reactions of the whales demonstrate their auditory sensitivity but also emphasise that anthropogenic activities in pristine narwhal habitats must be carefully managed if healthy narwhal populations are to be maintained. Although the study represents a short period in the life of the whales, the results are impressive because whales respond at long distances from boats (> 10 km). These results will be useful for regulating seismic exploration and shipping.
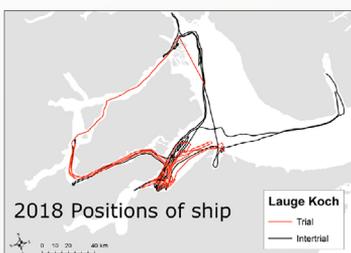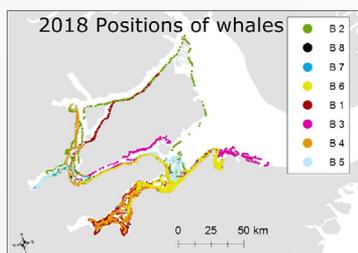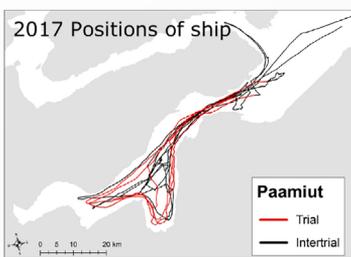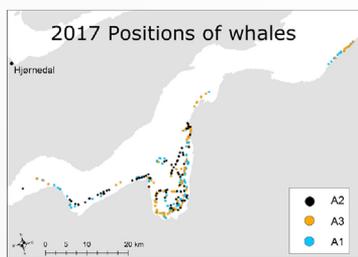
Upper panel, left: tracks of three whales subject to airgun trials in 2017.

Upper panel, right: track of the seismic vessel. Red lines indicate effort with air gun shooting (trials) and black lines indicate effort without air gun activity (intertrials).

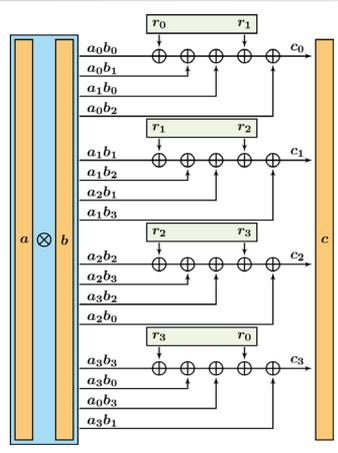*Lower panel, left: positions of eight narwhals tracked in 2018.*

Lower panel, right: positions of the seismic vessel in 2018.

SCIENTIFIC RESULTS OF THE TEAMS

High-order masking - Protecting embedded cryptography against side-channel attacks
› CAS^{3}C^3 team

A 4-NI multiplication gadget for binary fields.

In cryptography, a "grey-box" *attack model* considers adversaries that possess some kind of physical access to the device where the algorithms are implemented ; it is relevant for small handheld devices such as smartcards and mobile phones, which can easily be approached or "borrowed" to carry-out an attack.

Masking is a countermeasure against such adversaries that makes it harder to learn the secret data on which the algorithms operate by simply "observing" a computation. It consists in replacing the basic operations (such as addition or multiplication) used in the algorithms by masked *gadgets* that hide their secret inputs with random *masks*.

A gadget is "high-order" if it uses many independent masks (for instance 7) ; doing so provides more security than a "low-order" gadget. However, those gadgets are also more expensive to implement, and it is often much costlier to verify that they actually provide the desired security level.

High-order masking is especially relevant for protecting implementations on high-end embedded processors, as found for instance on smartphones.

Physical measurements on such processors tend to have a low noise level, which makes attacks easier; implementations thus require more masks for adequate protection.

There is a strong need to provide countermeasures that are both efficient and formally proven to guarantee the absence of vulnerabilities in the actual implementation.

A description of a 7-SNI multiplication gadget, as input to the verification tool.

```
s00 r00 s01 s10 r01 s02 s20 r08 s03 s30 r09 s04 r20
s11 r01 s12 s21 r02 s13 s31 r09 s14 s41 r10 s15 r21
s22 r02 s23 s32 r03 s24 s42 r10 s25 s52 r11 s26 r22
s33 r03 s34 s43 r04 s35 s53 r11 s36 s63 r12 s37 r23
s44 r04 s45 s54 r05 s46 s64 r12 s47 s74 r13 s40 r20
s55 r05 s56 s65 r06 s57 s75 r13 s50 s05 r14 s51 r21
s66 r06 s67 s76 r07 s60 s06 r14 s61 s16 r15 s62 r22
s77 r07 s70 s07 r00 s71 s17 r15 s72 s27 r08 s73 r23
```

We have recently developed new techniques for verifying "binary" masking gadgets, which are the most commonly used in protecting symmetric cryptography systems [1]. These techniques are much faster than the previous state of the art, and allowed to validate or refute the security claims of some previously-unverified high-order gadgets.

We also designed and verified new gadgets that incur a lower overhead than previous alternatives, thus decreasing the cost of an adequate protection.

One of these was then used in a complete masked implementation at order 7 of the AES block cipher, and the concrete protection granted by the masking was evaluated through a series of physical measurements and statistical tests [2].

Verifying the security of masking gadgets remains an expensive task, which would be desirable to improve further.

Defining gadgets over "large" fields such as $\mathbb{F}256$ and applying these countermeasures in an automated flow also still constitutes a challenge.

[1] **Fast Verification of Masking Schemes in Characteristic Two**, N. Bordes and P. Karpman. EUROCRYPT 2021.

[2] **Electromagnetic Leakage Assessment of a Proven Higher-Order Masking of AES S-Box**, N. Bordes and P. Maistri. Euromicro Conference on Digital System Design (DSD), 2022.
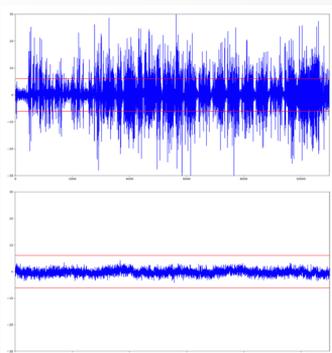
Univariate leakage test on an implementation with fixed masks (top) and random masks (bottom).
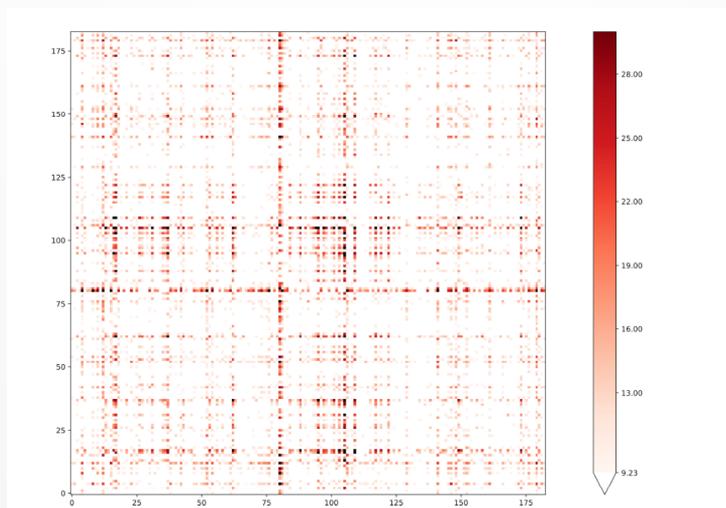
Bivariate leakage test on an implementation with fixed masks.

COMPUTING PLATFORMS AND VALORIZATION

Mission Exoplanets

› AIRSEA team

Mission Expoplanets poster.

«Welcome to the New Pioneer Recruitment Centre! We are looking for the future inhabitants of the bases that will be created on the newly discovered habitable planets. On these planets, you will have to protect their ecosystems, their biodiversity and promote sustainable development. In order to find out your suitability as a galactic inhabitant, you will now take several test modules.»

This is the catchphrase of **Mission Exoplanets**, a large game in the spirit of an escape game, in which participants must solve enigmas around interactive modules that deal with energy saving, permaculture, renewable energy, recycling and waste sorting. And behind these riddles, reasoning, logic, mental calculation, geometry, optimisation...

This game was developed by the association **La Grange des Maths** [1], in which several LJK teacher-researchers are strongly involved. **La Grange des Maths** aims to «de-dramatise» and «democratise» mathematics, through various actions aimed at schools and the general public. **Mission Exoplanets** was conceived in the context of group work at the IREM of Grenoble, and in collaboration with **La croisée des énigmes**, a company specialising in escape games.

The game is composed of 10 modules and occupies 80 to 100 m². It is aimed at all ages, from 12 years old, in teams of 2 to 4 players, and can accommodate up to thirty people simultaneously. It is designed to travel (it can be set up and dismantled in 2 or 3 hours; any cultural, associative or educational structure can rent it) and to arouse curiosity (a companion booklet provides teachers with elements to take up and extend the concepts involved in the game in class).

Since its launch in the spring of 2021, **Mission Exoplanets** has challenged more than 4.000 players in several secondary schools in Ardèche, Drôme and Isère, at the **Les Clévos Cité des Savoirs**, and on the Saint Martin d'Hères campus for the Science festival.

Future inhabitants finding their way through the galaxy.

[1] La Grange des Maths has developed educational kits for primary and secondary schools, whose activities have already been used by more than 30.000 children in the Grenoble education authority.

www.la-gange-des-maths.fr/mission-exoplanetes
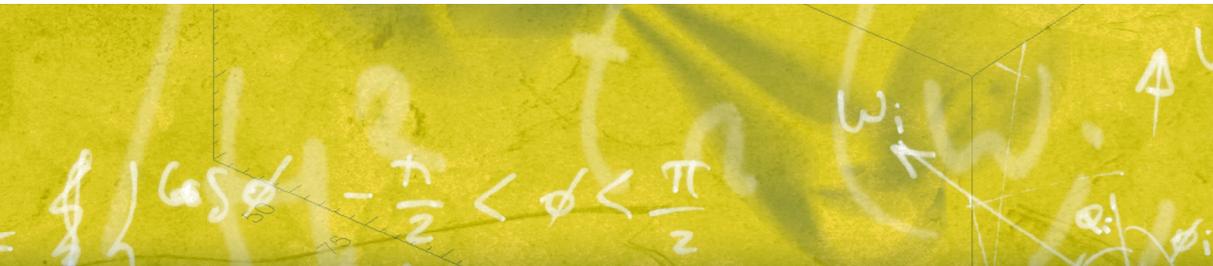
MicMap: computer assisted creation of mountain panorama maps

› MAVERICK team

In Europe and North America, panorama maps are widely used by mountain operators to promote their resorts. They played an important role in the development of winter sport tourism. Panorama artists who have become prominent masters in the field all share a similar creative process while achieving different styles in the end.

Producing a hand-painted panorama map is a challenging task, involving a broad range of skills. Even for masters such as Heinrich C. Berann or Pierre Novat, the production time for large paintings can take up to several months. Panoramists, though experts at crafting beautiful aerial maps of the mountain, are now a dwindling profession due to these constraints. Indeed, ski resorts rely more and more on computer graphics software to produce panoramas. However, 3D rendering systems lack the editing tools to enable the creation of convincing artistic panoramas and artists are often required to manually or digitally repaint parts of the rendered images to achieve the desired result.

In the MicMap project, we work with Arthur Novat, Pierre Novat's son, the most well known French panoramist, to produce a computer graphics model dedicated to panorama maps. This model includes three major components: (LIGHT) a dedicated shading model that allows to create plausible and legible 3D rendering views of the terrain, (CARTO) a set of methods to add all needed cartographic data such as the roads, buildings and ski tracks, and (DEFORM) a deformation model to unfold the terrain so as to emphasise the relevant points of interest of the landscape.

Based on our three components we can create dedicated applications for various clients: ski stations, tourist offices, graphics designers... Our solution takes as input real geographic data, such as those of IGN or OpenStreetMap, to generate panorama maps that are geolocalised and rendered in real-time. It allows various use cases going from itinerary computation, to flow visualisation or real time view of open ski tracks. MicMap is currently funded as a maturation project with Grenoble INP and the Linksium SATT.

A panoramic view of Grenoble where the terrain has been deformed so as to show the distant relief. The data are taken from IGN and all the rendering and deformation are automatic and realtime.
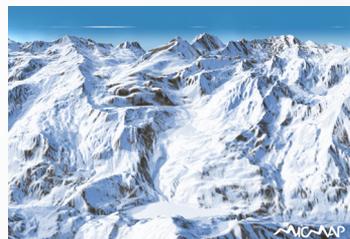
A highly deformed panoramic view of espace Killy. The terrain data has been manually modified based on the original panorama of atelier Novat. The lighthing and colors are computed in realtime.
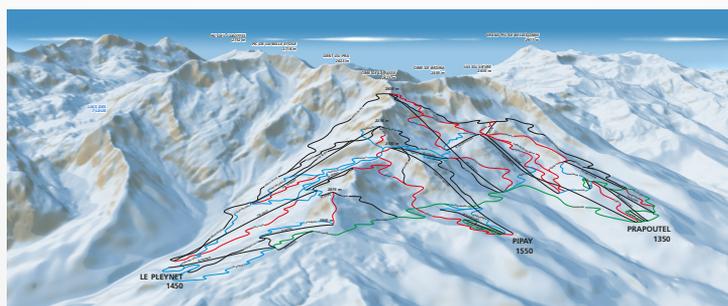
A ski map of the 7 Laux: The terrain has been rendered with our LIGHT model and the ski tracks have been manually drawn by Arthur Novat based on data from OpenStreetMap.

COMPUTING PLATFORMS AND VALORIZATION

Device and method for knowledge transfer of an artificial neural network
› SVH team

From now on, they do not solely belong to authors of science fiction beset by a techno-dystopic vision of the world, nor are they confined in mysterious research offices seeking day and night for optimisation of their shaky performances. No, neural networks – for better or for worst – are well established at the heart of novel scientific results but are also present in numerous daily applications.

Some of these applications are necessarily embedded. Some of these applications need to be updated regularly to adapt to new situations. Which ones will you ask me?

Let's take autonomous vehicles as an example. M. Clumsy is highly satisfied with his self-driving car except that, next to his home, the car has a systematic violent deviation next to a street art painting (Figure 1), round the corner. The system is probably «thinking» that someone is just about to throw an object on the roadway.

Which options does M. Clumsy have?

1. suffer in silence,

2. beg for a software fix in a near future,

3. manually intervene to correct the vehicle's trajectory.

In the latter option, one would hope that M. Clumsy does not have to correct his car's behaviour each time he passes by the painting, but rather that the system "learns" after some time which is the correct way to drive there. The risky part here is that the system may now "think" that throwing stones on the roadway is no longer an obstacle, giving M. Clumsy a unique experience while passing by the protests against the next political reform.

1. Flower Thrower, Banksy.
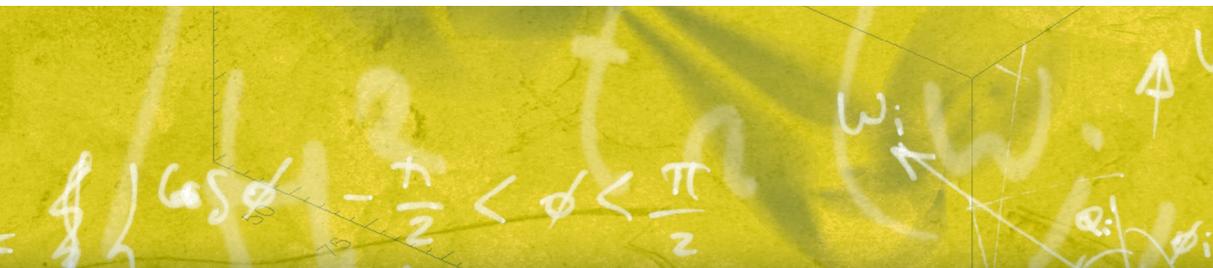
A better solution would be to train the system on how to react to new situations while recalling lessons learned during previous training examples (i.e. avoid a phenomenon called catastrophic forgetting).

A classical way of doing it is to refresh the system from time to time with previous training examples. However this would probably call for a full training set of thousands of hours of recorded driving in the car, which makes this solution not materially tractable.

Here is where our innovation comes into play: we show that learning a training set with a specific type of neural network (called auto-encoders) allows to regenerate artificial samples with enough quality to allow the system to recall previous situations while learning new ones. The information of the training set is highly compressed as it is stored only in the weights of the auto-encoder, allowing to embed it in resource-frugal systems.

The way to generate the samples with the auto-encoder is slightly surprising: we first start from a random sample (say a drawn from a Gaussian distribution), feed it to the auto-encoder, and re-inject the output of the auto-encoder at the input, iteratively, several times (Figure 2). In order to explain why this method works, we show in a side publication [1] that under optimality conditions, only very approximately met in practice, the sampling amounts to a Monte Carlo Langevin sampling of the training set. The current patent shows that in practice, even though these theoretical conditions are not met, the obtained samples are still useful and exploitable for practical application.
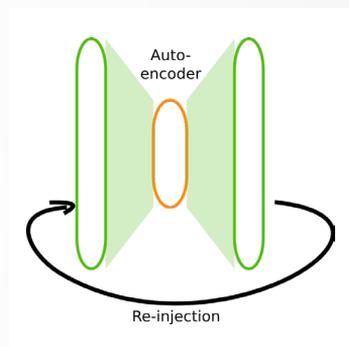
Although M. Clumsy's example makes my point easy, innovating the industry of self-driving cars is not really my cup of tea. If you do not drink this type of beverages either, let me suggest that:

- there are much more important applications that could benefit from this type of mechanisms, like surgery [2],

- beyond embedded systems, our patent is a contribution to general methods aiming at reducing the memory and computational footprints when re-training learning systems (an active area of research called frugal transfer learning).

This patent stems from a collaboration between the LJK and CEA Grenoble. May this patent be used in good, moral, and environment-friendly ways!

2. Re-injections in auto-encoders.

[1] *Generalization of iterative sampling in autoencoders*, M. Solinas, C. Galiez, R. Cohendet, S. Rousset, M. Reyboz, and M. Mermillod. 19th IEEE International Conference on Machine Learning and Applications (ICMLA), 877–882, 2020.
[2] *Autonomous Robot Improves Surgical Precision Using AI, Nvidia Technical*. Blog accessed March 26th 2023

COMPUTING PLATFORMS AND VALORIZATION

## Pooling covid 19

› SVH team

During the first containment of 2020, the CNRS has set up the MODCOV19 platform [1] in order to encourage the coordination of modelling actions in France to overcome the crisis. In this context, we have a collaboration on grouped tests with the LAGA* and the Centre de Physique Théorique Turing**.

In France, we have mainly performed individual tests for SARS-CoV-2 or COVID19. The idea of pooling is to test a group of people by mixing the samples: if the test is negative, then the group is assumed to be healthy, if not, there is at least one sick individual and we can test the members of the group individually or repeat subgroups until contaminated individuals are detected. In the case of perfect tests, this technique reduces the cost of testing and allows a large number of people to be tested more quickly. On the other hand, if the tests are not perfect, there is a risk of loss of sensitivity.

*Schematic principle of pooling.
© J.-F. Rupprecht et Centre de physique théorique (CNRS/Aix-Marseille Université/Université de Toulon).*
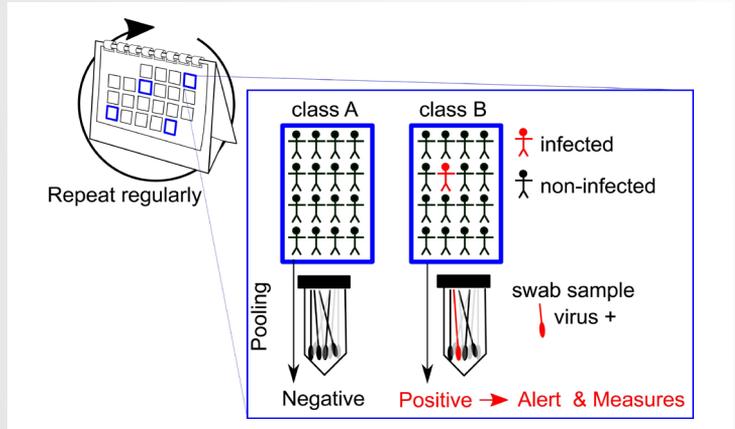
This technique was used by R. Dorfman in 1943 for the detection of syphilis and was used at the beginning of the COVID19 crisis in California, Germany, India, Israel and Rwanda, especially. In France, the High Council for Public Health (HCSP) very quickly issued an unfavourable opinion on its use, notably because of the loss of sensitivity, according to the HCSP [2]. In response to the HCSP's questions, the GROUPOOL group was set up. It is within this framework that the collaboration took place.
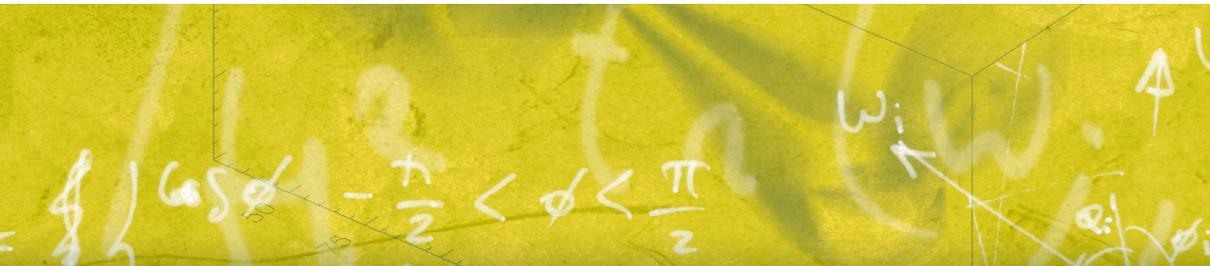
For COVID19, the test carried out is an RT-PCR consisting of a certain number of cycles in which the target viral DNA sequences are duplicated each time with the aim of making them detectable. If the virus is present enough initially in the sample, the machine should detect it after a while. However, if the machine runs too many cycles, it may detect impurities. To avoid false positives, the machines are stopped early enough at the expense of possible false negatives if the initial viral load is too low.

In their 2021 paper, Brault, Mallein and Rupprecht mathematically modelled the influence of dilution on test efficiency and deduced that the sample size shifts the number of cycles according to a logarithmic function. To estimate the loss of sensitivity, they sought to model the distribution of the number of cycles by taking into account the censoring effect due to the maximum number of cycles, which also allowed them to estimate a minority of the false negative rate in the population even before dilution. Finally, they proposed procedures for early detection of virus introduction in a closed community.

This work also led to a CNRS news, various popularisation articles to raise public awareness and, with others, helped to change the HCSP's opinion on its use.

[1] https://modcov19.math.cnrs.fr/
[2] https://www.hcsp.fr/Explore.cgi/AvisRapportsDomaine?clefr=828

LAGA: Univesité Sorbonne Paris Nord

**Centre de Physique Théorique Turing: Aix Marseille Univ and CNRS*

Group testing as a strategy for COVID-19 epidemiological monitoring and community surveillance, V. Brault, B. Mallein, and J.-F. Rupprecht. PLoS computational biology, 17(3), e1008726, 2021.

The detection of defective members of large populations, R. Dorfman. The Annals of mathematical statistics, 14(4), 436-440, 1943.

$d_{cens} = 41.5$

$d_{cens} = 40.5$

$d_{cens} = 39.5$

$d_{cens} = 38.5$
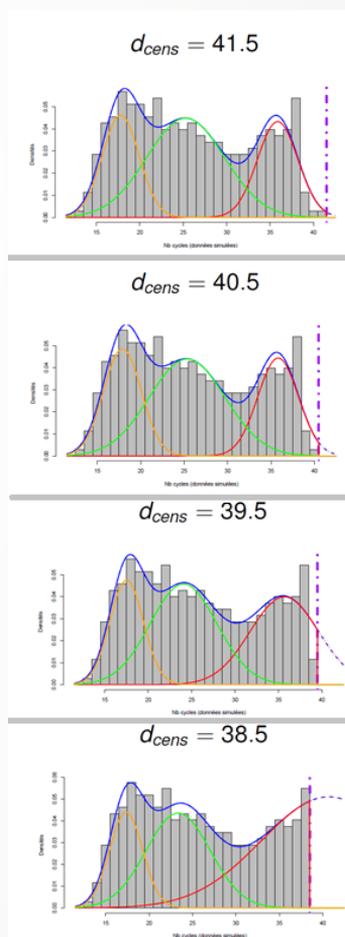
Results of the modelling on real data according to different values of the maximum number of cycles. The curves represent the different modelling of the viral load.

AWARDS

2021

Caroline Bligny (SCALDE team)

CNRS collective Cristal awarded to a team of engineers for the development of a dynamic mapping of clinical trials related to the Covid-19 pandemic.

Charles Dapogny (EDP team)

Michelin Foundation Hope Prize - Academy of Sciences 2021 for his research focusing on the modelling, analysis and numerical simulation of problems related to the optimisation of the shape of mechanical parts.

Romain Vergne, Nolan Mestres and Joëlle Thollot (MAVERICK team)

12th Out Of Labs challenge for the project Stylised Panoramas: Computer assisted creation of mountain panorama maps.

Clément Pernet (CAS³C³ team)

Journal of Complexity Best Paper Award 2021 for "Deterministic computation of the characteristic polynomial in the time of matrix multiplication".

Pierre Gaillard (THOTH team)

Outstanding paper awards for "Continuized Accelerations of Deterministic and Stochastic Gradient Descents, and of Gossip Algorithms" NeurIPS 2021 (Advances in Neural Information Processing Systems 34).

2022

Stefanie Hahmann (ANIMA team)

Gay Lussac-Humboldt Prize.

Gilles Bareilles (DAO team PhD student)

Dodu Prize for his paper "Méthodes de Newton pour l'optimisation composite non-lisse".

Emmanuel Rodriguez, Stefanie Hahmann, Mélina Skouras (ANIMA team) et Georges-Pierre Bonneau (MAVERICK team)

Best Paper Award at SPM 2022 (Solid and Physical Modelling 2022) for "Computational Design of Laser-Cut Bending-Active Structures".

Bruno Grenet (CAS3C3 team) with Pascal Giorgi, Armelle Perret du Cray and Daniel Roche.

Distinguished Paper Award for "Sparse Polynomial Interpolation and Division in Soft-linear Time". ISSAC'22.

Mathilde Caron (STEEP team)

ELLIS PhD Award 2022 (European Laboratory for Learning and Intelligent Systems) and Accessit of the Gilles Kahn prize for her thesis "Self-supervised learning of deep visual representations" prepared at LJK in partnership with Facebook AI Research (FAIR).

Jean-Baptiste Keck (EDP team)

Winner of i-PhD prize "Numerical modelling and High Performance Computing for sediment flows" under the supervision of Georges-Henri Cottet and Iraj Mortazavi.

François-Rémy Mazy and Pierre-Yves Longaretti (STEEP team)

Best student paper award for "A Formally and Algorithmically Efficient LULC change Model-Building Environment" at GISTAM 2022 (International Conference on Geographical Information Systems Theory, Applications and Management).

Léa Vienot (STEEP team internship)

École Polytechnique Prize for her Master thesis "Demonstrators for the analysis of socio-technical alternatives " [hal-03867864].

Boris Thibert (EDP team)

"Infinity always finds its way". Geometry of smooth fractals - Photo-realistic rendering from a digital computation. This image is one of the winners of the 2022 La preuve par l'image (LPPI) photography competition.

Mickaël Ly (ELAN team)

Second best PhD award, for his PhD entitled "Static Inverse Modelling of Cloth" in November 2022 from the French GdR IG-RV.

Édouard OUDET (EDP team)

Institut Universitaire de France Promotion Senior 2022. Fundamental Chair in Shape Optimisation.

CONFERENCES & WORKSHOPS

2021

Workshop Cryptocurrencies & blockchains: risks vs. stability

March 5 Grenoble

https://cybersecurity.univ-grenoble-alpes.fr/the-institute/news-events/all-events/workshop-cryptocurrencies-blockchains-risks-vs-stability-829444.htm

ABC in Svalbard, Grenoble mirror

April 12-13 remotely

https://sites.google.com/view/abcinsvalbard-grenoble-mirror/

MASCOT 2021 Meeting

April 28-30 remotely

https://www.gdr-mascotnum.fr/mascot21.html

BioHasard 2021

May 20 - June 11 remotely

https://biohasard2020.sciencesconf.org/

7ᵗʰ International Conference on Event-Based Control, Communication, and Signal Processing

June 22-25 Krakow

https://ebccsp2021.org/

Maths and AI: MIPT-UGA young researcher workshop
July 1-2 remotely

https://sites.google.com/view/mipt-uga-ai-workshop

Workshop spectral problems, inverse problems, and more
October 22 Grenoble

https://edp-ljk.imag.fr/event/spectral2021/

CONFERENCES & WORKSHOPS

2022

ENBIS Spring Meeting 2022

May 19-20 Grenoble

https://conferences.enbis.org/event/16/

Anthropocene FACTS spring school

July 23-27 Grenoble

http://anthropocenefacts.org/spring-school/

Statistical Inference and Convex Optimization

June 12-16 Autrans

https://sites.google.com/view/sico22/

Archipel 2022: "Systemic risks, trajectories, and levers for action"

June 20-23 Grenoble

https://archipel.inria.fr/

8th International Conference on Event-Based Control, Communication, and Signal Processing

June 23-26 Krakow

https://ebccsp2022.org/

Methods and Tools for Audio-Visual Processing and Human Robot Interaction
August 23 Montbonnot

https://project.inria.fr/avbot/workshop/

Workshop MODCOV
September 29 Grenoble

https://membres-ljk.imag.fr/Clementine.Prieur/news/MODCOV_Gre/Programme_MODCOVGRE.pdf

Journées d'Informatique Théâtrale 2022
October 10-11 Lyon

https://hal.inria.fr/JIT/

Graphyz 2022
October 16-19 Saline Royale of Arc-et-Senans

https://project.inria.fr/graphyz2/
https://team.inria.fr/elan/graphyz-2022-registration-opens-june-20th/
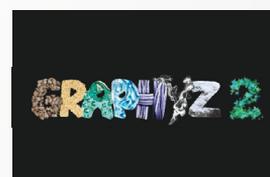
MASIM 2022
Thematic meeting on machine learning for structural bioinformatics
December 5-8 Paris

https://gt-masim.cnrs.fr/actions/thematic-meetings-ml-sampling/

Books
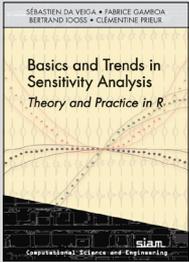
Basics and Trends in Sensitivity Analysis: Theory and Practice in R

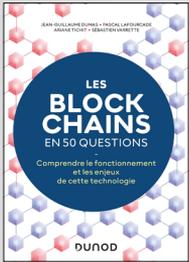Sébastien da Veiga, Fabrice Gamboa, Bertrand Iooss, Clémentine Prieur.

SIAM, 2021.
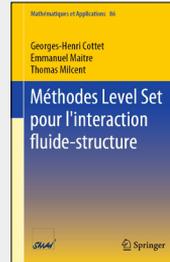
Méthodes Level Set pour l'interaction fluide-structure
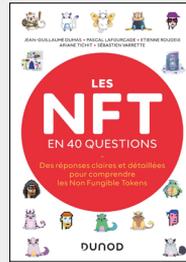
Georges-Henri Cottet, Emmanuel Maitre, Thomas Milcent.

Mathématiques et applications, vol. 86, Springer, 2021.

Les blockchains en 50 questions - 2nd edition

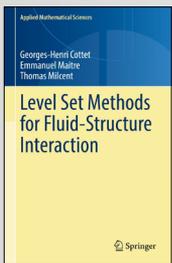Jean-Guillaume Dumas, Pascal Lafourcade, Ariane Tichit, Sébastien Varrette.

Dunod, 2022.

Les NFT en 40 questions

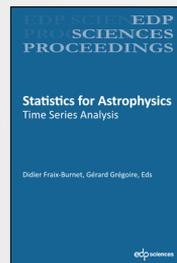Jean-Guillaume Dumas, Pascal Lafourcade, Etienne Roudeix, Ariane Tichit, Sébastien Varrette.

Dunod, 2022.

Level Set Methods for Fluid-Structure Interaction

Georges-Henri Cottet, Emmanuel Maitre, Thomas Milcent.

Applied Mathematical Sciences, Springer 2022.

Statistics for astrophysics: Time series analysis

Didier Fraix-Burnet, Gérard Grégoire.

EDP Sciences Proceedings, 2022.

Выпуклая оптимизация (Convex optimization)

Evgeniya Vorontsova, Roland Hildebrand, Alexander Gasnikov, Fedor Stonyakin.

MIPT, 2021.

Mission exploratoire sur les métavers

Adrien Basdevant, Camille François, Rémi Ronfard.

Ministère de la Culture ; Ministère de l'Économie, des Finances et de la Souveraineté industrielle et numérique, 2022.

Some key figures for LJK

243 lab members
of which 66 professors and assistant professors
58 researchers
95 doctoral students and postdocs
24 technical and administrative staff members
and around 50 trainees each year

150 publications in peer-reviewed journals per year
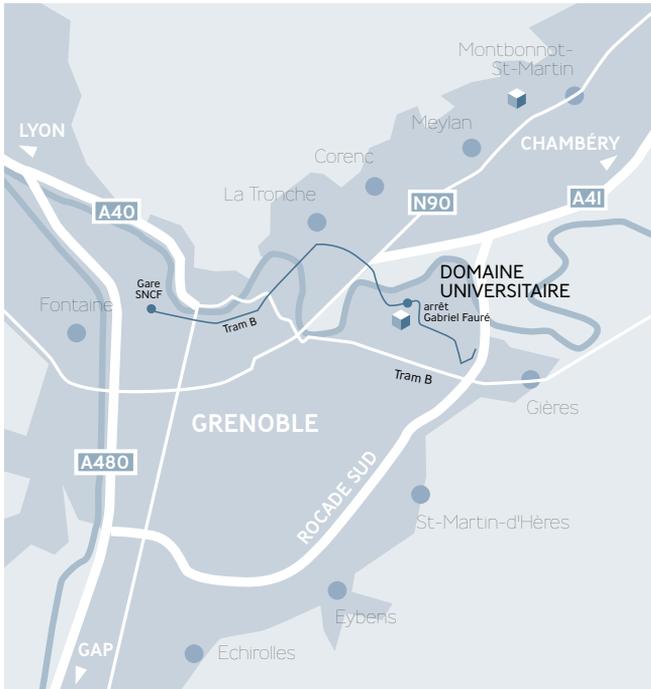
8 books in 2021-2022

24 projects sponsored by the French ANR

8 European projects,
including 3 ERC individual grants

LJK

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MATHÉMATIQUES APPLIQUÉES · INFORMATIQUE

ljk.imag.fr

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