AIMS-Cameroon Mathematics and its Applications Meeting (ACMAM)

AIMS | African Institute for Mathematical Sciences CAMEROON

Happening on **January 12-14, 2022**

Alessio Figalli,
(ETH, Zurich),
Keynote Lecturer

Enrique Zuazua,
(University of Erlangen–Nuremberg (FAU)), Keynote Lecturer

Gabriel Peyré,
(CNRS and Ecole Normale Supérieure), Keynote Lecturer

Harbir Antil,
(CMAI-George Mason University), Keynote Lecturer

Marco Cuturi,
(Google Brain , CREST-ENSAE), Keynote Lecturer

Quentin Merigot,
(Université Paris-Saclay), Keynote Lecturer

ACMAM: Create a strong networking environment among academia, industry, and the national laboratories.

2022 Theme: **Mathematics for Machine Learning**

Federal Ministry of Education and Research

DAAD Deutscher Akademischer Austauschdienst
German Academic Exchange Service

AIMS | African Institute for Mathematical Sciences SOUTH AFRICA

MESSAGE FROM THE ACTING CHAIR

Chair of the Organizing Committee
Jean-Daniel Djida

The AIMS-Cameroom Mathematics and its Applications Meeting (ACMAM) is a maiden edition of an initiative geared towards fostering the ties between academia, industry, and the national laboratories. The workshop will take place at the Research Center Campus of the African Institute for Mathematical Sciences, at Crystal Gardens, Limbe, Cameroon on January 12-14, 2022, with more than 300 persons to participate both physically and remotely.

Sponsored by Deutscher Akademisher Austausch Dienst/German Academic Exchange Service (DAAD), and supported by AIMS-Cameroon and AIMS South Africa, the 03-day event will include a series of plenary and semi-plenary talks, as well as contributed talks.

World-renowned cultural and research institutions, a thriving creative scene and its rich history make Limbe a popular place to live, work and travel. The venue of the workshop is located at the heart of Limbe, interestingly, one of the host cities for the much-anticipated 2022 Africa Cup of Nations tournament hosted by Cameroon for the first time in 50 years.

We are pleased to receive International Master's and Ph.D. students, Postdocs, and Researchers as they join us to enjoy Limbe's unlimited recreational possibilities, an open-minded and international atmosphere, and a lot of exciting Mathematics.

RESEARCH AT AIMS-CAMEROON

The AIMS-Cameroon Research Centre, located in the campus of AIMS-Cameroon at Crystal Garden in Limbe, Cameroon, came into existence in 2017, and is supported by Alexander von Humboldt and DAAD in collaboration with universities in Cameroon and financed by the German Federal Ministry of Education and Research (BMBF).

Our mission is to conduct and foster exceptional research as well as national Lab, industry, continental, and international collaborations.

The areas of research include Mathematical Analysis, Nonlinear Analysis, Partial Differential Equations, Climate Sciences, Shape Optimization, Control Theory, Machine Learning and Big Data, with a broad range of applications to real-world problems such as environmental pollution, coastal erosion, urban, networks and problems arising in some local companies.

Our goal is to provide a unique learning experience for students and researchers; provide a space for mathematical scientists to work and interact with local and international researchers within the country and AIMS students; and to foster ties between Academia, National Labs, Industry, and Government.

WHY MEET TO DISCUSS MATHEMATICS AND ITS APPLICATIONS?

The AIMS-Cameroon Mathematics and its Applications Meeting (ACMAM) is an initiative to introduce students and early-career researchers to the current trends in Mathematics and its application in Machine Learning as well as to create a strong networking environment among academia, industry, and the national laboratories. This hybrid (face-to-face and online) workshop will be held annually under the title "AIMS-Cameroon Mathematics and its Applications Meeting" (ACMAM) and will see ten distinguished speakers give lectures on their research topics.

With a focus on **Fundamental Sciences (Mathematics) and its applications to Machine Learning,** the meeting will comprise mini-courses targeted toward students and early career researchers as well as Public Lectures. There will be additional talks and contributions by guest speakers.

OBJECTIVE AND OUTCOME

The extensive successful use of Machine Learning, Digital Twin, Deep Learning, Neural Networks in communications and information theory, and Climate Sciences in recent years has been remarkable. However, from a mathematical viewpoint, an adequate theoretical understanding of its primary governing principles is still missing in many situations.

ACMAM therefore aims to introduce participants to some of the mathematical foundations of Data Science in general and Machine Learning in particular.

This Workshop (meeting) will focus on these associated theoretical aspects, and provide a list of interesting open problems related to industry and flourishing local companies.

By the end of the meeting, participants would be sufficiently armed with the mathematical tools and techniques to potentially undertake theoretical research in Mathematics and its applications in Machine Learning from scratch.

Scientific Program: Wednesday, Jan 12 – Friday, Jan 14 2022

Program Overview

Wed, Jan 12, 2022	Thu, Jan 13, 2022	Fri, Jan 14, 2022
7:00-8:00 am Breakfast and Registration	**7:00 - 8:00 am** Breakfast	**7:00 - 8:00 am** Breakfast
8:00-9:00 am Welcome address + AIMS model by the Center President (Mama Foupouagnigni)	**8:00 - 9:30 am** Plenary Speaker Lecture (Marco Cuturi)	**8:00 - 9:30 am** Plenary Speaker Lecture (Enrique Zuazua)
9:00-10:30 am Plenary Speaker Lecture (Alessio Figalli)	**9:30 - 10:30 am** Invited Speaker Lecture (Marc Sedjro)	**9:30 - 10:30 am** Invited Speaker Lecture (Olivier Menoukeu Pamen)
10:30-12:00 am Plenary Speaker Lecture (Enrique Zuazua)	10:30 – 12:00 am Invited Speaker Lecture (Franca Hoffmann)	**10:30 – 12:00 am** Plenary Speaker Lecture (Enrique Zuazua)
12:00 -1:30 pm Plenary Speaker Lecture (Gabriel Peyré)	**12:00 – 1:00 pm** Invited Speaker Lecture (Ralph Chill)	**12:00 – 1:00 pm** Invited Speaker Lecture (Mouhamed Moustapha Fall)
1:30 - 2:30 pm Lunch (AIMS Research Center)	**13:00 - 2:00 pm** Lunch (AIMS Research Center)	**13:00 - 2:00 pm** Lunch (AIMS-Center)
2:30 - 3:00 pm Participant Talk 1	2:00 – 3:30 pm Invited Speaker Lecture (Mahamadi Warma)	**2:00 – 3:30 pm** Plenary Speaker Lecture (Quentin Merigot)
3:00 - 4:00 pm Plenary Speaker Lecture (Harbir Antil)	3:30 - 4:30 pm Plenary Speaker Lecture (Harbir Antil)	**3:30 - 4:00 pm** Coffee Break
4:00 - 4:20 pm Coffee Break	**4:30 - 4:50 pm** Coffee Break	4:00 – 5:30 pm Plenary Speaker Lecture (Enrique Zuazua)
4:20 - 5:50 pm Plenary Speaker Lecture (Harbir Antil)	4:50 – 6:20 pm Plenary Speaker Lecture (Harbir Antil)	**5:30 – 6:00 pm** Closing Ceremony + Remarks (Jean-Daniel Djida and Mark Sedjro)
5:50 - 6:20 pm Participant Talk 2		**6:00 - 7:00 pm** Cocktail (AIMS Research Center)

KEYNOTE SPEAKERS

Harbir Antil
(George Mason University, USA)

Harbir Antil (George Mason University, USA)

Plenary Talk

Title. Mathematics of Optimization Based Deep Learning

Abstract. The purpose of this self-contained mini-course is to create a mathematical understanding of Deep Learning (DL). The DL problems will be cast as constrained optimization problems. In particular, the deep neural networks (DNNs) will be modeled as discrete differential equations with continuous analogues. The resulting problems are ordinary (or partial) differential equation constrained optimization problems. Various algorithms will be discussed to solve the resulting problems.

This framework is highly advantageous as it can capture DNNs such as residual neural networks, dense neural networks, etc. It provides a mathematical framework to study the stability of DNNs. Finally, it enables us to use the developments that have taken place over the last two decades in PDE constrained optimization.

The following topics will be covered:

- Computer vision
- Least square regression and logistic regression
- Universal approximation theorem
- Linear and nonlinear classification
- Deep neural networks
- Stochastic gradient descent and accelerations
- Convolutional neural networks (CNNs)
- Residual neural networks (ResNets)
- Implementation aspects
- Applications in complex flows, imaging, data assimilation, and inverse problems

Prerequisites: Basic linear algebra, some familiarity with Python and MATLAB will be assumed.

Alessio Figalli
(ETH, Zurich)

Alessio Figalli (ETH, Zurich)

Plenary Talk
Title. Optimal transport: past, present, and future

Abstract. At the end of the 18th century, Gaspard Monge introduced the optimal transport problem to understand the most efficient way of transporting a distribution of material from one place to another to build fortifications. In the last 30 years, this theory has found various applications in many areas, both in mathematics and outside. In this talk, I will introduce this beautiful theory and present some selected applications.

Enrique Zuazua
(FAU, Erlangen-Nürnberg, Germany)

Enrique Zuazua (FAU, Erlangen-Nürnberg, Germany)

Plenary Talk
Title. Control and Machine Learning

Abstract. We address some of the problems arising in the modern theory of Machine Learning from a control theoretical perspective. We will mainly focus on the use of control techniques for the analysis of Deep Neural Networks as a tool to address, for instance, the problem of Supervised Learning. We shall also discuss numerical implementation issues and formulate some interesting open problems.

Gabriel Peyré
(CNRS and Ecole Normale Supérieure, France)

Gabriel Peyré (CNRS and Ecole Normale Supérieure, France)

Plenary Talk
Title. Scaling Optimal Transport for High dimensional Learning

Abstract. We address some of the problems arising in the modern theory of Machine Learning from a control theoretical perspective. We will mainly focus on the use of control techniques for the analysis of Deep Neural Networks as a tool to address, for instance, the problem of Supervised Learning. We shall also discuss numerical implementation issues and formulate some interesting open problems.

Marco Cuturi
(Google Brain/CREST-ENSAE, France)

Marco Cuturi (Google Brain/CREST-ENSAE, France)

Plenary Talk

Title. Differentiating through Transport

Abstract. Computing or approximating an optimal transport cost is rarely the sole goal when using Optimal Transport in applications. In most cases the end goal relies instead on solving the Optimal Transport problem and studying the differentiable properties of its solutions w.r.t. to arbitrary input variables. After a short introduction to Optimal Transport, I will present in this talk recent applications that highlight this necessity, as well as concrete algorithmic and programmatic solutions to handle such issues.

Quentin Merigot
(Universite Paris-Saclay, France)

Quentin Merigot (Universite Paris-Saclay, France)

Plenary Talk

Title. Optimal quantization and optimal transport

Abstract. In this talk, we will review the optimal quantization problem, which occurs in many applied fields, including but not limited to meshing, numerical integration, approximation, and clustering. This problem is formulated as a non-convex minimization problem, namely find a finitely supported probability measure which approximates best, in the sense of quadratic optimal transport, a reference probability density ρ. This minimization problem is often solved numerically using Lloyd's method, also called k-means method in statistics. We will consider a variant of this problem where we try to approximate ρ as well as possible using uniform measures over a set with fixed cardinal N, which is also motivated by applications in data science. We will show that this second minimization problem, while still non-convex, behaves better with respect to optimization algorithms.

INVITED SPEAKERS

Franca Hoffmann
(AIMS-Rwanda, Rwanda)

Franca Hoffmann (AIMS-Rwanda, Rwanda)

Title: Covariance-modulated optimal transport and ensemble Kalman methods

Abstract: We study the properties of a generalized Wasserstein metric space, where the L^2 inner product of the dynamical formulation is weighted by the covariance metric locally in probability space. Such a metric arises for example as the mean-field limit of certain Ensemble Kalman methods for solving Inverse Problems, such as the Ensemble Kalman Sampler, providing a suitable gradient flow structure

Marc Sedjro
(AIMS-South Africa, South Africa)

Marc Sedjro (AIMS-South Africa, South Africa)

Title: Monge-Ampere equations on a free boundary domain

Abstract: We consider a class of Monge-Ampere equations in a two-dimensional domain with a free boundary. Here, the value of the unknown function is prescribed on the free boundary. From a variational point of view, these equations describe an optimal transport problem from an a priori undetermined source domain to a prescribed target domain. We prove the existence and uniqueness of a variational solution to these Monge-Ampere equations under a singularity condition on the density function on the source domain. Furthermore, we provide regularity results under some conditions on the prescribed domain.

Ralph Chill
(Technische Universität Dresden, Germany)

Ralph Chill (Technische Universität Dresden, Germany)

Title: Asymptotic behaviour of finite-dimensional gradient systems with applications to Machine Learning

Abstract: We review some recent applications of the theory of gradient systems to Machine Learning, especially about long-time convergence of discrete algorithms. One of the most powerful tools in the study of longtime behaviour of time-continuous gradient systems is the Lojasiewicz gradient inequality for the underlying energy function. The validity of the Lojasiewicz gradient inequality (for example, when the energy function is real analytic) near every point of its domain yields that every bounded solution of the corresponding gradient system converges to an equilibrium point. We study the analogue of this result for discrete algorithms, and we discuss an application arising from Machine Learning.

Olivier Menoukeu Pamen
(University of Liverpool, UK)

Olivier Menoukeu Pamen (University of Liverpool, UK)

Title: Takagi type functions and dynamical systems: the smoothness of the SBR measure and the existence of local time

Abstract: We investigate Takagi-type functions with roughness parameter γ that are Hölder continuous with coefficient $H = \log \gamma / \log (½)$. Analytical access is provided by an embedding into a dynamical system related to the baker transform where the graphs of the functions are identified as their global attractors. They possess stable manifolds hosting Sinai-Bowen-Ruelle (SBR) measures. We show that the SBR measure is absolutely continuous for large enough γ. Dually, where duality is related to time reversal, we prove that for large enough γ a version of the Takagi-type curve centered around fibers of the associated stable manifold possesses a square integrable local time.

Mouhamed Moustapha Fall
(AIMS-Senegal, Senegal)

Mouhamed Moustapha Fall (AIMS-Senegal, Senegal)

Title: Regional fractional Laplacian

Abstract: We consider nonlocal operators, obtained from symmetric stable processes, describing motions of random particles in a region Omega which are censored to jump outside Omega. While particles can jump inside the domain, they are either reflected inside or killed when they reach the boundary of the domain. A typical examples of such operators are the "regional fractional Laplace operator subject to Neumann or Dirichlet boundary conditions. A natural generalization to jump processes was recently found by Bogdan, Burdzy and Chen. In this lecture, we shall investigate the properties of these nonlocal operators and the regularity results of solutions to the corresponding Poisson problem.

LIST OF LOCAL PARTICIPANTS

Full Name	Country	Affiliation
Alphonse Houwe	Cameroon	
Annette Flavie Ngo Babem	Cameroon	University of Kassel
Antoine-Marie Bogso	Ghana	Aims Ghana
Armel Tchamba	Cameroon	
Bayang Jules Paulin	Cameroon	University of Maroua
Bénite Isaoura	Cameroon	National Committee for Development of Technologies
Blaise Baidi	Cameroon	University of Maroua
Bob James Bogny Kenfack	Cameroon	
Cabrel Teguia	Cameroon	University of Douala
Camelle Kabiwa Kadje	Cameroon	Aims Cameroon
Cédric Iverdon Hameni Nkwayep	Cameroon	University of Douala
Christophe Le Roy Nsiaka Meliphe	Cameroon	
Damien Wohwe Sambo	Cameroon	University of Ngaoundéré
Edouard Yonga	Cameroon	
Eglantine Muriel Takongmo Fosokeng	Cameroon	University of Yaounde1
Elie Bertrand Megam Ngouonkadi	Cameroon	University of Buea
Emel Boris	Cameroon	University of Douala
Etienne Djoukeng	Cameroon	University of Buea
Gaël Nguepy Dongmo	Cameroon	University of Dschang
Ghislaine Flore Kabadiang Ngon	Cameroon	University of Yaounde I
Guy Foghem	Germany	Dresden University of Technology
Guy Phares Fotso Fotso	Cameroon	University of Dschang
Hermann Sockeng Koussok	Cameroon	
Huguette Laure Wamba Makeng	Cameroon	National Advanced School of Engineering of Yaounde
Igor Collins Djouda Paguem	Cameroon	University of Yaoundé 1
Jake Leonard Nkeck	Cameroon	University of Buea
Jean Baptiste Patenou	Cameroon	University of Dschang
Jean Marie Fotso Fotso	Cameroon	University of Dschang
Jodelle Letricia Kemajou Wandja	Cameroon	
Joel Etaya Ebot	Cameroon	University of Buea

Full Name	Country	Affiliation
Joseph Romaric Cheuteu Tazopap	Cameroon	University of Douala
Justin Moskolai Ngossaha	Cameroun	
Kagho Zanguim Jaurel	Cameroon	University of Bamenda
Lesly Fougang Tsoptio	Cameroon	University of Yaounde 1
Magaret Aude Donfack Melachi	Cameroon	University of Douala
Marie Rose Youbi Kemmogne	Cameroon	University of Yaounde
Martial Kabong Nono	Cameroon	University of Dschang
Mohamed Mounton	Cameroon	AIMS
Moussa El-Khalil Kpoumie	Cameroon	University of Ngaoundere
Myke Vital Temgoua Sao	Cameroon	University of Yaounde 1
Nadiane Nguekeu Metepong Lagpong	Cameroon	University of Douala
Ngonda Tchamba Felix	Cameroon	
Pavel Yomi	Cameroon	University of Yaounde 1
Pélérine Tsobgni Nyawo	Cameroon	University of Buea
Régine Constella Imandi	Cameroon	Imandi Régine Constella
Samuel Mouchili	Cameroon	University of Yaounde 1
Serge Didier Takoukam Soh	Cameroon	University of Yaounde I
Serge Guy Nana Engo	Cameroon	University of Yaounde I
Servais Ngo'O Mbang	Cameroon	
Sthyve Junior Tatho Djeanou	Cameroon	University of Douala
Yannick Kouakep Tchaptchié	Cameroon	University of Ngaoundere
Yannick Malong	Cameroon	National Higher Polytechnic School of Douala

ORGANIZERS

Jean-Daniel Djida (AIMS-Cameroon)
Marc Sedjro (AIMS South Africa)

LOCAL SUPPORT TEAM

Mama Foupouagnigni,
Boniface Nkemzi,
Floriane Mefo Kue,
Landry Djomenye,
Jake Leonard Nkeck

SPONSORS

Deutscher Akademischer Austausch Dienst/German Academic Exchange Service (DAAD),
AIMS-Cameroon,
AIMS South Africa.

Federal Ministry of Education and Research

DAAD Deutscher Akademischer Austauschdienst German Academic Exchange Service

AIMS | African Institute for Mathematical Sciences CAMEROON

AIMS | African Institute for Mathematical Sciences SOUTH AFRICA

African Institute for Mathematical Sciences (AIMS – Cameroon)
Tel: (+237) 33 33 33 63. www.aims-cameroon.org