# SAMBa Conference 2021 – Poster Title and Abstract

**Eric Gutierrez**

Title: Convergence Properties of a Randomized Primal-Dual Algorithm with Applications to Parallel MRI

Abstract: The Stochastic Primal-Dual Hybrid Gradient (SPDHG) is an efficient algorithm to solve some nonsmooth large-scale optimization problems. We prove its almost sure convergence for convex but not necessarily strongly convex functionals. To test its performance, we look into applications to parallel Magnetic Resonance Imaging reconstruction. Numerical results show that, for a range of settings, SPDHG converges significantly faster than its deterministic counterpart.

**Eileen Russell**

Title: Faraday Wave-Droplet Dynamics: A Discrete-Time One-Dimensional Model

**Margaret Duff**

Title: Solving Inverse Imaging Problems using Generative Machine Learning Methods

Abstract: Solving an inverse problem is the task of computing an unknown physical quantity from indirect measurements found via a forward model. Inverse problems are everywhere in science and engineering, including many imaging problems such as CT, MRI, denoising, super-resolution and inpainting. Interesting inverse problems are nearly always ill-posed. In particular, sometimes the data recovered is not sufficient to solve the reconstruction problem accurately and some form of prior knowledge is required.

Generative models learn, from observations, approximations to high-dimensional data distributions. State-of-the-art methods include variational autoencoders and generative adversarial networks. The learnt distribution can then be used as a prior when solving the inverse problem, providing additional information and ensuring solutions are feasible. This work explores three different methods for combining a generative model in the regulariser part of a variational regularisation approach to inverse problems. The hope is that these methods will produce good image reconstruction results for ill-posed inverse problems while remaining flexible to changes in the forward problem.

**Simone Appella**

Title: Adaptive Mesh methods for the Poisson Equation on the L-shaped domain.

Abstract: Solutions of elliptic PDEs on non-convex domains feature singular behaviour near re-entrant corners. This results in a poor accuracy for the solution obtained via numerical methods on uniform meshes [1]. One solution is to employ different adaptive mesh strategies to increase the spatial accuracy in that region. We will focus on two strategies: local mesh refinement and moving mesh methods, also known as h- and r-adaptive methods. The former alters the degrees of freedom of the mesh, whereas the latter relocates a fixed number of mesh points on the domain. The Poisson equation is discretised with the Symmetric Interior Penalty discontinuous Galerkin (SIP-dG) method. The novelty of this research consists in deriving a a-posteriori error estimator, which will drive the mesh adaptation, in the framework of weighted Sobolev spaces [2].Numerical experiments evidence the effectiveness of the a-posteriori estimate for both mesh strategies in terms of accuracy.

**Laura Oporto**

Title: Physical-statistical model for air quality prediction from traffic data

Abstract: This work aims to predict pollution levels within a city by combining deterministic and statistical modelling. The focus of this research is on the impact of traffic emissions on air pollution. The goal is to obtain realistic traffic emissions by analysing traffic flows on networks with limited data. These emissions are then combined with meteorological data as inputs in a dispersion model. Finally, pollution data will be used to estimate the unknown parameters in the model and to consider other factors involved in air pollution that are not considered in the deterministic approach.

**Marco Murtinu**

Title: Should you always follow the leader?

**Tosin Babasola**

Title: Mathematical modelling approach to understanding resilience of cocoa farming.

Abstract: A delay differential mathematical model that described the flowering, pod formation and harvesting phase of a cocoa crop is presented. The stability analysis was considered, and we determined the condition necessary for stable equilibrium. In addition, we displayed the result that shows the behaviour of the yield over time using the formulated model and the available data. The yield plots show similar trend and it's observed that there is a rapid flower growth and slow decay after a period of prolonged rainfall.

**Rosa Kowalewski**

Title: Euler-Poincaré equations for non-conservative fluid dynamics - Variational methods, geometric mechanics, fluid dynamics, nonconservative mechanics

Abstract: Dating back to W.R. Hamilton, the dynamics of a physical system are captured in an action functional, which by a variational principle yields the equations of motion of the system. The equations of motion, Euler-Lagrange equations, can be further reduced to the Euler-Poincaré equations if the system underlies a symmetry. In contrast to the Euler-Lagrange equations, which are expressed in a particular coordinate system in Eulerian (spatial) coordinates, the Euler-Poincaré equations are formulated in the Lagrangian (material) reference frame and can therefore be written without the use of a particular coordinate system.

There are physical laws which can not be captured by the traditional Hamilton's principle: If the system involves non-conservative components the necessary time-symmetry is broken and Hamilton's principle is not valid. A recently developed formalism by Galley [1] allows the formulation of a variational principle for non-conservative systems, on an action functional of the doubled set of degrees of freedom. A 'potential' function, which couples the doubled variables, includes nonconservative interactions in the Lagrangian.

In this poster, we derive the Euler-Poincaré equations following from Galley's action principle for nonconservative fluid dynamics. In order to generalise the formalism to coordinate-free expressions, and to obtain deeper insight in the underlying geometry, we reformulate the principle in terms of deformations acting on the fluid manifold.

References

[1] Galley, Chad R. "Classical mechanics of nonconservative systems." Physical review letters 110.17 (2013): 174301.

**Edwin Watson-Miller**

Title: Discrete and Continuous Homoclinic Snaking

Abstract: There is a great deal of interest in nonlinear differential and difference equations that exhibit homoclinic snaking, in which solution curves of localised patterns 'snake' back and forth across a bifurcation diagram in a narrow region of parameter space. In this poster, we present two approaches for extending our understanding of snaking bifurcations in bistable nonlinear systems: (i) numerical techniques to understand limiting behaviours in solution structures, especially in discrete cases (lattices of coupled cells) in two and higher dimensions; and (ii) the use of exponential asymptotics to characterise the multiple-scales structure of the solutions and analytically describe the snaking phenomenon.

**Dan Miles**

Title: A Regression Approach to Reducing Dimensionality in Gaussian Networks

Gaussian Graphical Models, also known as Gaussian Networks, are commonly used in Statistics to encode a graphical relationship onto a multivariate Gaussian distribution. In practice, many applications manifest a high dimensionality combined with a sparse graph structure, which can hinder inference and high-level interpretation. However, as described through a crime data example, the implementation of a regression-based transformation through the log-likelihood function can efficiently and informatively infer a relationship between a high number of connected nodes (crime rates for different regions) with a smaller number of secondary variables (socioeconomic factors).

**Josh Inoue**

Title: Change point detection in spatio-temporal data

**Tom Davis**

Title: Finding the Lead Eigenfunction of a Linear Operator using Sequential Monte Carlo

Abstract: We consider a Sequential Monte Carlo algorithm that can be used for computing the lead eigenfunction of a non-negative linear operator defined on an arbitrary measurable space. This algorithm is motivated by a class of eigenvalue problems arising in the design of nuclear reactors.