Talk Titles and Abstracts – Wednesday 11 January

10.00-10.20: **Yingjing Feng** (University of Birmingham)

Talk Title: Machine learning on body surface potential mapping aided by computational modelling for personalized atrial fibrillation treatment

Abstract: Atrial fibrillation (AF) is the most common arrhythmia, with about 9% occurring over age 65. Catheter ablation therapy is the most effective treatment for AF. However, due to the complexity and inter-patient variability of AF mechanisms, within one year after the first catheter ablation, about 40 - 50% of patients still experience AF recurrence, substantiating the need for personalized treatment. Promising mapping tools to personalize the treatment of the patients include non-invasive electrical recordings of the patient torso, such as 12-lead electrocardiograms and 252-lead body surface potential maps. However, existing methods to analyze the torso potentials have drawbacks including restricted interpretability and limited accuracy, as the problem of faithfully reconstructing the electrical waves in the atria using the torso potentials is mathematically ill-posed.

I will talk about how machine learning and computer models can be used to improve non-invasive mapping for guiding personalized AF ablation. In particular, computer models were developed to aid the machine learning algorithms by providing a rich training dataset for predicting AF mechanisms and demonstrating the biophysical basis of the algorithms. Our algorithms broadened the scope of non-invasive mapping, and demonstrated great potentials in guiding mechanism-directed AF treatment and early AF detection.

10.20-10.40: **Lisa Maria Kreusser** (University of Bath)

Talk Title: Partial differential equations in biology and data science

Abstract: The recent, rapid advances in modern biology and data science have opened up a whole range of challenging mathematical problems which can be tackled by combining applied and numerical analysis. In this talk, I will discuss interacting particle models which have been popular in biological applications, for instance in the context of simulating realistic fingerprint patterns. I will demonstrate how similar models can be used in semi-supervised learning and network science.

10.40.11.00: **Yue Wu** (University of Strathclyde)

Talk Title: Randomised numerical schemes

Abstract: In this talk, I will introduce randomised numerical schemes for a wide range of differential equations with time-irregular coefficients. The initial scheme considered is a randomised Runge-Kunta for Caratheodory ODEs. Our motivation for studying Caratheodory type initial value problems stems from the fact that certain rough differential equations that are driven by an additive noise can be transformed into a problem of this form. it is well-known that there is lack of convergence for deterministic algorithms in this case, and our proposed method in [1], by incorporating stratified Monte-Carlo simulation into the corresponding deterministic ones, showed that even with very mild conditions, the order of convergence can be at least half with respect to the Lp norm.

The idea was later extended to stochastic settings. We proposed a drift-randomized Milstein method to achieve a higher order approximation to non-autonomous SDEs where the standard smoothness and growth requirements of standard Milstein-type methods are not fulfilled. We also investigated the numerical solution of non-autonomous semilinear stochastic evolution equations (SEEs) driven by an additive Wiener noise. Usually quite restrictive smoothness requirements are imposed in order to achieve a high order of convergence rate. To relax such conditions, we proposed a novel numerical method in [3] for the approximation of the solution to the semilinear SEE that combines the drift-randomization technique from [2] with a Galerkin finite element method. It turns out that the resulting method converges with a higher rate with respect to the temporal discretization parameter without requiring any differentiability of the nonlinearity. Our approach also relaxes the smoothness requirements of the coefficients with respect to the time variable considerably.

Recently, we pushed this idea to Caratheodory delay ODEs (CDDEs), where a randomised Euler scheme is proposed to approximate the exact solution [4]. It is worth mentioning that, mainly due to CDDEs being considered interval-by-interval, we developed a suitable proof technique that is based on mathematical induction. The randomised technique from [2] is only applicable for the initial inductive step; as the systems iterate over time, a different strategy is required to handle the effect of the delay variable.

[1] Kruse, R. and Wu, Y., 2017. Error analysis of randomized Runge–Kutta methods for differential equations with time-irregular coefficients. *Computational Methods in Applied Mathematics*, *17*(3), pp.479-498.

[2] Kruse, R. and Wu, Y., 2019. A randomized Milstein method for stochastic differential equations with non-differentiable drift coefficients. Discrete and Continuous Dynamical Systems - Series B, 24(8), pp.3475-3502.

[3] Kruse, R. and Wu, Y., 2019. A randomized and fully discrete Galerkin finite element method for semilinear stochastic evolution equations. *Mathematics of Computation*, *88*(320), pp.2793-2825.

[4] Difonzo, F.V., Przybyłowicz, P. and Wu, Y., 2022. Existence, uniqueness and approximation of solutions to Carath\'eodory delay differential equations. *arXiv preprint arXiv:2204.02016*.