University of Reading SIAM-IMA Student Chapter Conference

Monday 7th June

11 AM – 12 PM

Prof. Francoise Tisseur, University of Manchester
"What are nonlinear eigenvalue problems and how to solve them?"
Abstract:
Given a matrix-valued function F that depends nonlinearly on a single parameter z, the basic nonlinear eigenvalue problem consists of finding complex scalars z for which F(z) is singular. Such problems arise in many areas of computational science and engineering, including acoustics, control theory, fluid mechanics and structural engineering. In this talk I will discuss some important mathematical properties of nonlinear eigenvalue problems and then present recently developed algorithms for their numerical solution.

12 – 12.30 PM

Dominic Emery, Keele University
"Elasto-capillary beading of soft cylindrical tubes"
Abstract:
In fluid mechanics, surface tension is the architect of many fascinating phenomena such as droplet formation and water walking insects. Whilst the influence of surface tension on fluids is widely appreciated, in solids it is generally overlooked. Indeed, in stiff materials, surface tension effects are negligible and can be safely ignored. However, surface tension can be a driving force in the large deformation of extremely soft materials such as gels and biological tissue on the nano to milli-scale. A geometry of particular interest is the slender solid cylinder or tube, which is widespread in physiological systems from nerve fibres to "tunnelling nanotubes" which connect migrating cells. In this talk, we consider the localized beading instability which these tubes develop under the combined action of surface tension and axial stretching, and discuss our treatment of this phenomenon as a bifurcation problem under the framework of non-linear elasticity. We show that this instability takes the initial form of a bulge or a neck, depending on the loading scenario, after which an axial propagation into a "two-phase" kink-wave solution occurs.

12.30 – 1 PM

Henry Jaspars, Robert Gordon's College
"The Shortest Vector Problem and Applications"
Abstract:
In this presentation, I will show how contemporary advances in finding the shortest vector in a lattice (the Shortest Vector Problem) can be applied to number theory, with particular focus on the integer factorisation problem, and its applications in cryptanalysis. A proof of Minkowski's Theorem and the corresponding bounds in the Shortest Vector Problem is presented, and a motivating application to supply an alternate proof of Fermat's theorem on sums of two squares is shown. Following this, computational methods for constructing concrete solutions, such as the Lenstra-Lenstra-Lovasz (LLL) algorithm, are demonstrated. Finally, an exposition into recent developments in lattice reduction over Schnorr matrices for prime factorisation is presented.

Tuesday 8th June

11 AM – 12 PM

Dr. Naratip Santitissadeekorn, University of Surrey

"Uncertainty quantification for time-series of count data and influence network reconstruction"

Abstract:

A multivariate Hawkes process is widely used to model mutual excitation within a network where each node is described by a one-dimensional Hawkes process and the links represent the strength of influence. For example, large-amplitude earthquakes could excite bursts of aftershocks within an earthquake network. Inference of a multivariate Hawkes process typically requires a large batch of time-stamp data. However, there is a dearth of research work for filtering of count data.

This talk will present my recent work that develops an ensemble-based filtering approach for the time-series of Poisson count data. The new approach is applicable to discrete-time Hawkes processes in particular and the most conditional intensity process in general. The talk will demonstrate its utility to reconstruct an influence network from a real-world example.

12 – 12.30 PM

Stephen Falconer, University of Surrey

"Forecasting GP Flu consultations using Dynamic Mode Decomposition and the Ensemble Kalman Filter"

Abstract:

The abundance of data in the modern world has led to what been described in recent years as a data revolution. The vast majority of this data exists in a very high dimension which has motivated the need for more data-driven algorithms, such as Dynamic Mode Decomposition (DMD). Once a model has been created, as fresh measurements arrive data assimilation techniques like the Ensemble Kalman Filter (EnKF) are required to optimally update the model and it's predictions using this new information. We combine these 2 algorithms in the DMDEnKF and use it to forecast the number of Flu consultations GP's will see each week.

12.30 – 1 PM

Arianna Salili-James, Brunel University London

"Taking Shape: Analysis and Classification of Object Outlines using Shape Analysis"

Abstract:

There is no doubt that humans and other animals can not only recognise shapes but also differentiate shape from form. The latter is what aids us in classifying objects by eye, which is usually done in conjunction with more detailed descriptions of the object, such as patterns within. Subsequently, this leads to two questions which carve the basis of our work: (i) can an algorithm classify shapes in the same way a human does, and (ii) is the shape of an object alone sufficient for performing analysis and classification? To answer these questions, we investigate and compare traditional linear methods with diffeomorphic shape analysis methods that quantify differences between shapes on a series of real-world datasets. We provide an introduction and overview of the field of shape analysis, particularly, methods of shape matching. We are interested in analysing the shape of an object; crucially this means that we will not be studying landmarks as is often done with real-world data. Instead, we define the shapes as embeddings into R2 and work with the shape space of these curves using methods that are seldom applied to real-world data. This work is done in collaboration with Stephen Marsland (Victoria University of Wellington) and Armand Leroi (Imperial College London).

Wednesday 9th June

11 AM – 12 PM

Prof. Jan Sieber, University of Exeter

"Equations describing delay effects, and their applications in climate science"

Abstract:

Typically one expects negative feedback to have a stabilising effect on a dynamical system. However, when this feedback acts with a non-negligible delay this is often not the case. One observes oscillations (periodic or chaotic) instead. In climate science delayed negative feedbacks have been suggested as an underlying mechanism for climate variability at decadal, multi-decadal, and multi-thousand-year scale (El-Nino Southern Oscillations, Atlantic Multidecadal Oscillations, ice ages). I will explain in which sense (otherwise ordinary) differential equations with delay occupy a place between ordinary differential equations and partial differential equations, how they come up from physical modelling and what their typical properties are.

[Material I present in this talk comes from collaboration with Swinda Falkena (currently PhD student in Reading), Courtney Quinn (CSIRO) and Henk Dijkstra (Utrecht).]

12 – 12.30 PM

Umberto Maria Tomasini, École Polytechnique fédérale de Lausanne (EPFL)

"Predictors and Predictands of Linear Response in Spatially Extended Systems"

Abstract:

The goal of response theory, in each of its many statistical mechanical formulations, is to predict the perturbed response of a system from the knowledge of the unperturbed state and of the applied perturbation. A new recent angle on the problem focuses on providing a method to perform predictions of the change in one observable of the system by using the change in a second observable as a surrogate for the actual forcing. Such a viewpoint tries to address the very relevant problem of causal links within complex system when only incomplete information is available. We present here a method for quantifying and ranking the predictive ability of observables and use it to investigate the response of a paradigmatic spatially extended system, the Lorenz '96 model. We perturb locally the system and we then study to what extent a given local observable can predict the behaviour of a separate local observable. We show that this approach can reveal insights on the way a signal propagates inside the system. We also show that the procedure becomes more efficient if one considers multiple acting forcings and, correspondingly, multiple observables as predictors of the observable of interest.

12.30 – 1 PM

Rhys Thompson, University of Reading

"Automated reconstruction of transient waveforms using the Synchrosqueezing transform and Hessian-based image feature detection, applied to Pc5 ultralow frequency (ULF) wave pulsations in ground magnetometers"

Abstract:

Time-frequency representations (TFRs) are powerful tools able to separate periodic components and their underlying properties within a signal when time localization is desired. Sophisticated techniques have been developed to automatically extract information at the appropriate instantaneous frequencies, however, they require the (known number of) oscillatory components to persist for the duration of the signal. In many real-world applications transient waveforms are of interest, with limited pre-existing knowledge of observed signals. In this paper we present an algorithm to automatically extract transient waveforms from Synchrosqueezing TFRs using Hessian-based feature detection filters, to which frequency extraction techniques can then be applied. Performance is demonstrated for both idealized test cases and the detection of Pc5 pulsations within ground magnetometer time series for radiation belt physics.