Dynstoch 2014
10th – 12th September 2014

Organising Committee: Murray Pollock (Warwick), Gareth Roberts (Warwick), Michael Sørensen (Copenhagen)

Contents

BUILDING KEY (Map numbers correspond to main University map)

Arden	1 G2	Senate House	57 E5
Argent Court	2 I3	Sherbourne	58 C2
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• *Costa*		• *Westwood Teaching and Lecture Theatre*	76 I2/J2
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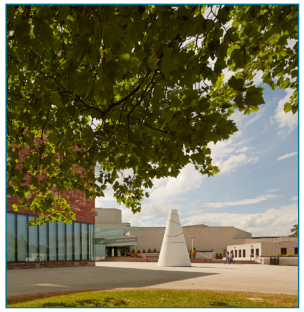
SYMBOLS

- University Buildings
- Student Residences
- Car Parks
- Building Entrances
- Wheelchair Access
- Controlled Access
- Footpaths
- Footpaths/Cycleways
- One way Road
- Bus Stop
- No Entry
- Lakes
- Food Outlets

Important Postcode Information

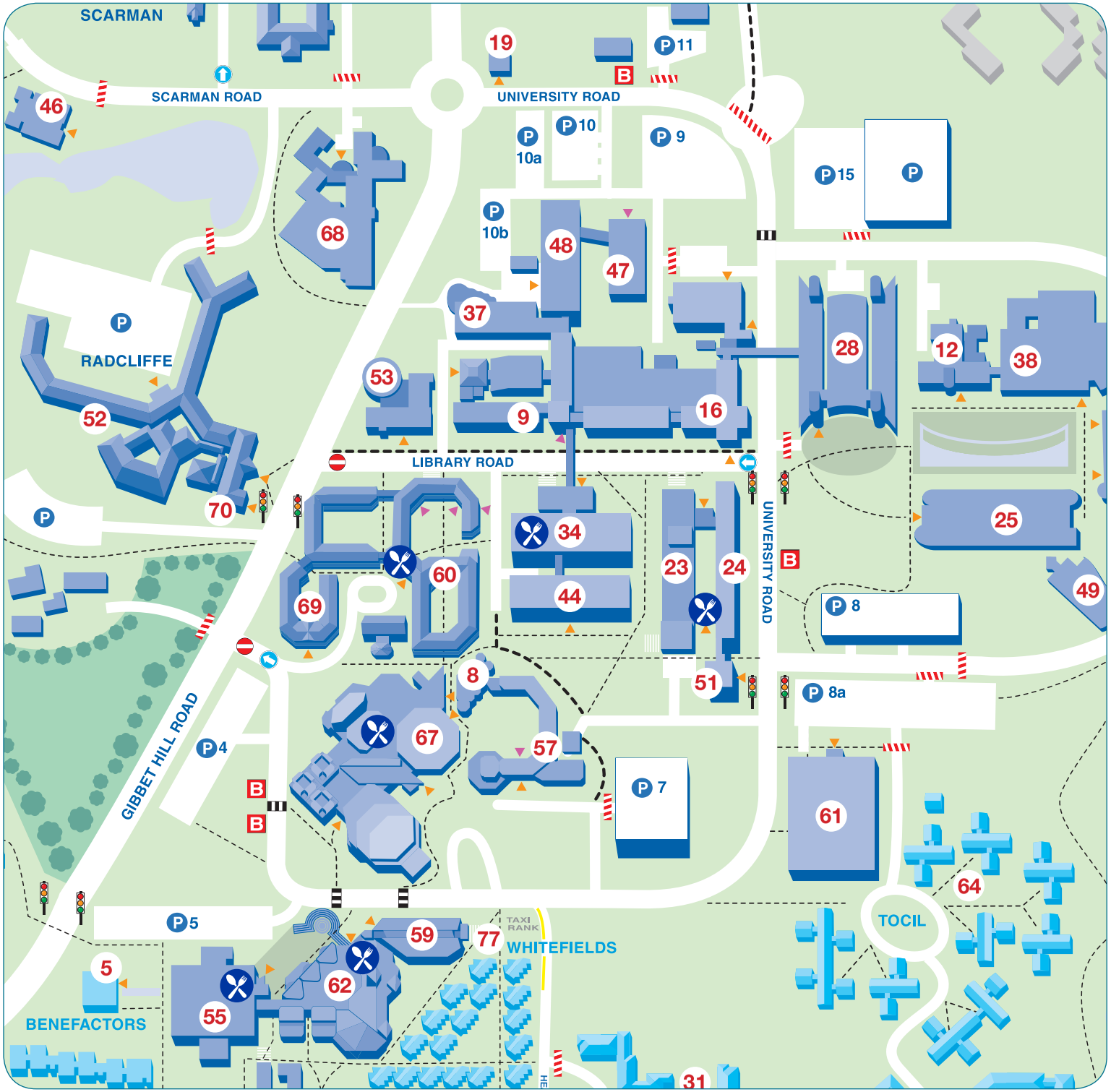
CV4 7AL directs you to Gibbet Hill Road, the main road which runs through the University. Radcliffe, Scarman and main campus (the Conference Park) are signposted from this road.

CV4 8UW directs you to Kirby Corner Road where Arden is signposted.



67. Warwick Arts Centre

62. New Conference Reception for 2014



23. Humanities

Building Key

1 Administrative Details

1.1 Conference Webpages

- http://www.warwick.ac.uk/dynstoch2014

1.2 Registration and Venue

- **Registration (incl. lunch):** 12-1pm, Wed. 10th Sept., Maths & Stats Building, Lobby.
- **Talks:** Maths & Stats Building, [MS.02].
- **Poster Session & Wine Reception:** 4.45-6.30pm, Wed. 10th Sept., Maths & Stats Building, Lobby.
- **Breakfast (Participants with on-campus accommodation only):** 7.30-9am, Rootes Social Building.
- **Lunch (Thursday and Friday):** 12.15-2.15pm, Mathematics and Statistics Building, Lobby.
- **Dinner (Wednesday):** 7.30pm, Rootes Social Building (Rootes Restaurant).
- **Conference Dinner (Thursday):** 7.30pm, Rootes Social Building (Panorama Room).
- **Conclusion:** 4pm, Friday 12th September.

1.3 Getting Here

- Information on getting to the University of Warwick from Coventry, as well as from other directions locally and further afield, can be found at http://www.warwick.ac.uk/about/visiting/
- See Appendix A & B for further details

1.4 Accommodation

- Accommodation is in en-suite rooms on campus in either the Arthur Vick, Bluebell or Jack Martin residences (on the campus map Here). Keys can be collected from the Conference Reception in the Student Union Atrium. All rooms have linen and toiletries. Kitchen facilities are available although meals are provided throughout the workshop. Rooms will be available after 15:00 for check in. All bedrooms must be vacated by 9:30am on the day of departure.
- See Appendix A & B for further details

1.5 Internet Access

- **Campus:** Wireless access is most easily available via eduroam — http://www.eduroam.org/ — which is supported across most of the Warwick campus. Speak to one of the organisers for details of other options.
- **Accommodation:** Wireless access is available, ask for log-in details whenever you check-in to your accommodation.

1.6 Start.Warwick

- The Start.Warwick app (available for iPads, iPhones and Android devices) provides useful information on travel and an interactive map of the campus amongst other things.

1.7 Facilities - See Map

- **Supermarket, Food and Drink Outlets:** `http://www.warwickretail.com`
  - See Appendix C for opening times.
- **Arts Centre:** `http://www.warwickartscentre.co.uk`
- **Sports Centre:** `http://www.warwick.ac.uk/sport/`
- **Health Centre:** `http://www.uwhc.org.uk`
- **Pharmacy:** Students Union Atrium

2 Help, Information & Telephone Numbers

2.1 Department

- **Address:** Department of Statistics, University of Warwick, Gibbet Hill Road, Coventry, CV4 7AL
- **Telephone:** 024 7652 4553
- **Fax:** 024 7652 4532
- **Webpage:** `http://www.warwick.ac.uk/stats`

2.2 Emergency Numbers

- **Emergency:** Internal - 22222; External - 024 7652 2222
- **Security:** Internal - 22083; External - 024 7652 2083
- **Organiser:** Internal - 73436; External - 024 7617 3436 (Murray Pollock)

2.3 Transport

- **Swift Taxis (Coventry):** 024 7676 7676
- **Trinity Street Taxis:** 024 7699 9999
- **National Rail Enquiries:** 08457 484 950

3 Timetable

All activities will take place in the Mathematics & Statistics Building, with talks in room MS.02 (signposted from lobby), unless otherwise stated.

3.1 Wednesday 10th September

Time	Speaker	Title	Pg
12:00	**Registration & Lunch**	**-**	**-**
13:00	**Welcome**	**Welcome: Gareth Roberts (Warwick)**	**-**
13:15	Joris Bierkens	Non-reversible Metropolis-Hastings and its mixing properties	9
13:45	Reinhard Höpfner	Ergodicity for strongly degenerate stochastic systems, with application to stochastic Hodgkin-Huxley models	12
14:15	Kengo Kamatani	Rate optimality of Random walk Metropolis algorithm in high-dimension with heavy- tailed target distribution	13
14:45	**Coffee Break**	**-**	**-**
15:15	Arnaud Gloter	LAMN property for discretely observed S.D.E. driven by stable Lévy processes	10
15:45	Ester Mariucci	Asymptotic equivalence for time-inhomogeneous jump-diffusion processes and white noise	14
16:15	Jeannette Woerner	Testing for jumps in stochastic volatility models	20
16:45	**Poster Session**	**Wine and light refreshments will be provided**	**-**
	Tobias Berg	Reconstruction Algorithm for Branching Diffusions with Immigration	22
	Jere Koskela	Approximately optimal importance sampling for Lambda-coalescents	22
	Gwennaëlle Mabon	Adaptive deconvolution on the nonnegative real line	22
	Fanni Nedényi	Change-Point Detection in Parametric Stochastic Models	23
	Murray Pollock	Exact Simulation in a Nutshell	23
	Christian Schmidt	U- and V-statistics for Ito Semimartingales	24
18:30	**Finish**	**-**	**-**
19:30	**Dinner**	**Rootes Social Building (Rootes Restaurant)**	**-**

3.2 Thursday 11th September

Time	Speaker	Title	Pg
7:30	**Breakfast**	**Rootes Social Building (Map Key 53)**	**-**
09:15	Markus Bibinger	Volatility estimation from high-frequency observations with irregular errors - Concepts and consequences	9
09:45	Nakahiro Yoshida	Volatility model selection	21
10:15	**Coffee Break**	**-**	**-**
10:45	Claudio Heinrich	Spectral Analysis of the Quadratic Variation of High Dimensional Itô Processes	11
11:15	Bezirgen Veliyev	Edgeworth expansion for the pre-averaging estimator	19
11:45	Mark Podolskij	Infill asymptotics for Levy moving average processes	15
12:15	**Lunch**	**-**	**-**
14:15	Moritz Schauer	Bayesian inference for discretely observed multi-dimensional diffusion processes	16
14:45	Charlotte Dion	Nonparametric estimation in a mixed-effect Ornstein-Uhlenbeck model	10
15:15	Masayuki Uchida	Hybrid multi-step estimators for stochastic differential equations from discrete observations	19
15:45	**Coffee Break**	**-**	**-**
16:15	Ana Prior	Parameter estimation of the drift of a two-regime bidimensional Ornstein-Uhlenbeck process with singular diffusion matrix	15
16:45	Paul Jenkins	Exact simulation of the sample paths of a diffusion with a finite entrance boundary	13
17:15	**Dynstoch Meeting**	**-**	**-**
18:30	**Finish**	**-**	**-**
19:30	**Conference Dinner**	**Rootes Social Building (Panorama Restaurant)**	**-**

3.3 Friday 12th September

Time	Speaker	Title	Pg
7:30	**Breakfast**	**Rootes Social Building (Map Key 53)**	**-**
09:15	Khalil El Waled	Parametric estimation problem for a time-periodic signal with additive periodic noise	20
09:45	Dominique Dehay	Bootstrap method for random sampled almost periodic process	10
10:15	**Coffee Break**	**-**	**-**
10:45	Nina Munkholt	Efficient Martingale Estimating Functions for Diffusions Sampled at High Frequency Over a Fixed Time-Interval	14
11:15	Mathias Trabs	Adaptive confidence bands for drift estimation of diffusions	18
11:45	Jakob Söhl	High-frequency Donsker theorems for Levy measures	17
12:15	**Lunch**	**-**	**-**
14:15	Luigi Spezia	Markov switching models for high-frequency time series from automatic monitoring of animals	18
14:45	Alexander Schnurr	Limit Theorems for Ordinal Pattern Dependence and Their Application to Medical/Biological Data	17
15:15	Yan Zhang	Variational Bayesian inference method in stochastic modelling of subcutaneous glucose concentration	21
16:00	**Finish**	**-**	**-**

4 Talk Abstracts

Volatility estimation from high-frequency observations with irregular errors - Concepts and consequences

Markus Bibinger
Humboldt-Universität zu Berlin

We consider discrete observations of a continuous-time diffusion process with i.i.d. observation errors. The target of statistical inference is the unknown volatility. This model is motivated by dynamics of intra-day financial data from limit order books. Best bid quotes, as an example, can be described as the sum of current underlying efficient prices and one- sided observation errors due to microstructure effects. While the statistical experiment with Gaussian observation noise is mostly well-understood, we shall reveal several intriguing properties of the so far unexplored setup with irregular errors, e.g. one-sided and exponentially distributed. It is shown that the optimal convergence rate of volatility estimation is much faster than in the classical Gaussian model. It is demonstrated how a rate-optimal estimator can be constructed. We propose a fully data-driven nonparametric estimation procedure.

Non-reversible Metropolis-Hastings and its mixing properties

Joris Bierkens
Radboud University

The classical Metropolis-Hastings (MH) algorithm generates reversible Markov chains, which is somewhat unfortunate since non-reversible Markov chains may have significantly better computational properties. The MH algorithm is extended to 'non- reversible Metropolis Hastings' (NRMH) so that it can generate non-reversible Markov chains, using the notion of a vorticity matrix. It is universal, in the sense that any finite Markov chain (reversible or non-reversible) satisfying a very mild condition on its directed graph structure, can be generated by the new approach.

It can be shown that, given a suitable 'vorticity structure', any chain obtained from Metropolis-Hastings can be altered in a simple way into a non-reversible chain that performs at least as well as the original chain in terms of asymptotic variance. This can be done without loss of the practical properties that make MH successful. Mixing times can be reduced significantly as compared to classical MH, and the relative effectiveness typically increases as a function of the problem size. The non-reversible nature of the resulting chains helps especially to overcome multi-modality in the target distribution.

The main challenge at the moment is to understand what vorticity structure gives the best improvement. It turns out to be a challenging task to understand mixing properties of non-reversible Markov chains, and in particular the improvements they provide over reversible chains. I will present my most recent results in this direction.

Bootstrap method for random sampled almost periodic process

Dominique Dehay
Université de Rennes

Let $\{X(t), t \in \mathbb{R}\}$ be an almost periodically correlated process that is observed along a random sampling scheme $\{T_k, k \geq 1\}$ independent on the process. Thus the observation is given by $\{(X(T_k), T_k)\}$. In this presentation we focus on the estimation of the cyclic means of $\{X(t), t \in \mathbb{R}\}$ under Poisson sampling scheme, and under regular sampling scheme with jitter phenomena. The asymptotic normality of the rescaled error of the estimator is shown. Additionally, the bootstrap method based on Circular Block Bootstrap is proposed. The consistency of the bootstrap technique is proved and the bootstrap pointwise and simultaneous confidence intervals for the cyclic means are constructed.

Nonparametric estimation in a mixed-effect Ornstein-Uhlenbeck model

Charlotte Dion
LJK (Grenoble) & MAP5 (Paris)

In the present work we propose two adaptive nonparametric procedures to estimate the density of the random effects in a mixed-effect Ornstein-Uhlenbeck model. In a first time we lead the selection of the bandwidth for a previous kernel estimator sets up in Comte et al (2013). In a second time we built an estimator using deconvolution tools. The selection of a final estimator among the collection is achieved with a Goldenshluger and Lepski's method, extended in our case. Indeed, the particularity is that each estimator depends on two parameters and both need to be chosen. Hence we set a new bidimensional penalized criterion. This produces an adaptive estimator, in a non-asymptotic context and an oracle inequality.

Finally we investigate the results on simulations and on a real database. Indeed, mixed-effect Ornstein-Uhlenbeck model is used to survey neuronal data: inter-spike-intervals. Besides, neuronal modelling could take advantage of the nonparametric estimation in order to obtain a closer model from observations.

LAMN property for discretely observed SDE driven by stable Lévy processes

Arnaud Gloter
Université d'Évry Val d'Essonne

We prove the Local Asymptotic Mixed Normality property from the high frequency observations $(X_{i/n})_{i=0,\ldots,n}$ of a continuous time process X solution of a stochastic differential equation driven by a pure jump Levy process. The proof of this result is based on a study of the asymptotic behavior, in small time, of the transition probability density of the process and of its logarithm derivative, using Malliavin calculus.

Spectral Analysis of the Quadratic Variation of High Dimensional Itô Processes

Claudio Heinrich
Aarhus University

We derive a limit for the spectral distribution of the realized covariance matrix

$$[X]_N^n = \sum_{i=1}^{n} (X_{\frac{i}{n}} - X_{\frac{i-1}{n}})(X_{\frac{i}{n}} - X_{\frac{i-1}{n}})^*$$

for a certain type of N-dimensional Ito processes X when the dimension of the process N and the number of observations n are large but of the same order of magnitude.

The realized covariance matrix is a popular estimator for the quadratic variation of Ito processes and is highly appreciated in practical applications. For many of these applications, especially in finance, the spectrum of the quadratic variation is particularly interesting. Examples are portfolio optimization and principal component analysis.

In the high dimensional case, however, the spectrum of the realized covariance matrix fails to be a good estimator for the spectrum of the quadratic variation itself. It is, thus, important to develop a better understanding of the spectral behavior of $[X]_N^n$ in the high dimensional case.

Our main Theorem identifies a limiting spectral distribution for $[X]_N^n$ when $n, N \to \infty$ with $n/N \to c > 0$. The proof of this theorem relies on methods from large dimensional random matrix theory. It extends the results of a famous paper by Yin and Krishnaiah. We use graph theory and the moment convergence theorem in order to determine the limiting spectral distribution by its moment sequence.

Ergodicity for strongly degenerate stochastic systems, with application to stochastic Hodgkin-Huxley models

Reinhard Höpfner[1], Eva Löcherbach[2], Michèle Thieullen[3]
Johannes Gutenberg-Universität Mainz[1], *Université de Cergy-Pontoise*[2], *Univerisité Pierre et Marie Curie*[3]

The classical deterministic Hodgkin-Huxley model (Hodgkin and Huxley 1951) for spiking neurons is a 4d dynamical system which admits a broad range of qualitatively very different regimes, depending on the structure of deterministic input $S(t)\,dt$. We take $t \to S(t)$ as a periodic function or a constant $S(\cdot) \equiv c$; desired periodic output (regularly spiking neuron) occurs only in special situations.

We consider a stochastic Hodgkin-Huxley (HH) system (`arXiv:1310.7373`, `arXiv:1311.3458`) which is a strongly degenerate 5d stochastic differential equation: conserving the classical 4 Hodgkin-Huxley equations we introduce –as 5th component- - an autonomous 1d stochastic process $(\xi_t)_{t\geq 0}$ whose *increments* $d\xi_t$ *replace the classical deterministic input* $S(t)dt$ *or* $c\,dt$. We take $(\xi)_{t\geq 0}$ as a mean-reverting OU or CIR-type diffusion with time dependent drift, mean-reverting towards $S(t)$ at time t. Now the given periodic function $t \to S(t)$ or the given constant c is coded as a *signal* in the semigroup of the stochastic Hodgkin-Huxley model. Control arguments show that with positive probability, our stochastic HH system can mimick the behaviour of almost every deterministic HH system (having input of form $S(t)dt$ where $S \neq S$) over time intervals of arbitrary fixed length.

As a 5d SDE driven by 1d Brownian motion, the stochastic HH system is strongly degenerate. Nevertheless, we can show that it admits continuous Lebesgue densities with respect to 5d Lebesgue measure, thanks to analyticity of all coefficients (and suitable determination of the 5d state space), and that weak Hoermander condition holds at all points of the state space. A Lyapunov function argument shows that some 5d compact K is visited infinitely often by the stochastic HH system in the long run. We use properties of a particular equilibrium point of deterministic HH with constant input $c = 0$ to construct a 5d point x^* which is attainable in a sense of deterministic control. Then, with respect to small neighbourhoods of x^*, we can do Nummelin splitting and obtain a unique Harris set and a unique invariant probability measure. Thus the stochastic HH system is positive Harris recurrent. This provides 'a natural setting' for key biological notions characterizing a neuron (such as: interspike times, spiking frequency, ...) in terms of invariant measure and of strong laws of large numbers. We illustrate this by formulating a Glivenko-Cantelli theorem for the empirical distribution of the length of interspike times.

Exact simulation of the sample paths of a diffusion with a finite entrance boundary

Paul Jenkins
University of Warwick

Diffusion processes arise in many fields, and so simulating the path of a diffusion is an important problem, being the first step of many methods of Monte Carlo statistical inference. It is usually necessary to make some sort of approximation such as Euler- type discretization, but a recently introduced class of algorithms, known as the exact algorithm and based on retrospective rejection sampling ideas, obviate the need for such discretization. However, the exact algorithm performs poorly on diffusions with a finite entrance boundary; specifically, regularity requirements on the drift coefficient are not always met, and even when they are met the computational requirements of the algorithm become unbounded whenever the diffusion approaches the boundary. This could be problematic, since entrance boundaries arise commonly—for example when we condition a diffusion not to cross a level. In this talk I will describe how to fix this problem. The key idea is that for these models the Bessel process of given dimension is a more suitable candidate process for the rejection algorithm than the more usually chosen Brownian motion, since the Bessel process is easy to simulate and can be chosen to match the entrance boundary of our target. The algorithm is illustrated by application to a general model of population growth.

Rate optimality of Random walk Metropolis algorithm in high-dimension with heavy- tailed target distribution

Kengo Kamatani
Osaka University

High-dimensional asymptotics of the random walk Metropolis-Hastings (RWM) algorithm is well understood for a class of light-tailed target distributions. We develop a study for heavy-tailed target distributions, such as the Student t- distribution or the stable distribution. The performance of the RWM algorithms heavily depends on the tail property of the target distribution. The expected squared jumping distance (ESJD) is a common measure of efficiency for light-tail case but it does not work for heavy-tail case due to integrability problem of the ESJD. For this reason, we use the rate of weak consistency as a measure of efficiency. When the number of dimension is d, we show that the rate for the RWM algorithm is d^2 for the heavy-tail case where it is d for the light-tail case. Also, we show that the Gaussian RWM algorithm attains the optimal rate among all random RWM algorithms. Thus no heavy-tail proposal can improve the rate.

Asymptotic equivalence for time-inhomogeneous jump-diffusion processes and white noise

Ester Mariucci
Laboratoire Jean Kuntzmann, Grenoble

We prove the global asymptotic equivalence between the experiments generated by the discrete or continuous observation of a path of a time inhomogeneous jump- diffusion process and a Gaussian white noise experiment. Here, the considered parameter is the drift function, and we suppose that the observation time T tends to ∞. The approximation is given in the sense of Le Cam's Δ-distance, under smoothness conditions on the unknown drift function. These asymptotic equivalences are established by constructing explicit Markov kernels that can be used to reproduce one experiment from the other.

Efficient Martingale Estimating Functions for Diffusions Sampled at High Frequency Over a Fixed Time-Interval

Nina Munkholt, Michael Sørensen
University of Copenhagen

We consider a real-valued diffusion process, which solves a stochastic differential equation with an unknown parameter in the diffusion coefficient. We investigate the asymptotic behaviour of estimators of this parameter, based on approximate martingale estimating functions, in a setup where the diffusion process is observed at high-frequency, with an increasing number of equidistant, discrete-time observations over a fixed time-interval.

We present a result showing that under our conditions, when suitably normalised, any consistent estimator will converge in distribution to a normal variance mixture. This distribution may be characterised as the product of two random variables, one of which is standard normally distributed, the other of which generally depends on the path of the diffusion process over the time-interval under consideration (and the true parameter).

In order to also obtain a limit distribution for use in statistical applications, we utilise the concept of stable convergence in distribution. Having shown that the convergence in distribution of the normalised estimator towards the normal variance mixture is stable, we note that this may be used to obtain convergence in distribution to a standard normal distribution of a slightly different transformation of the estimator.

We also argue that the estimating function may be chosen so that the estimator is efficient in a local asymptotic mixed normality sense, and we include an example where we compare the normal variance mixtures of the limit distributions corresponding to an efficient and an inefficient estimating function, respectively, by simulation.

Infill asymptotics for Levy moving average processes

Mark Podolskij
Aarhus University

We present some limit theorems for power variation of Levy moving average processes. We will see that the type and the mode of convergence depend on the behaviour of the kernel near 0, the considered power and the Blumenthal-Getoor index of the driving Levy process. The first order asymptotics consists of five different cases, some of which are highly non-standard. Furthermore, we will show a central limit theorem associated with one of those cases.

Parameter estimation of the drift of a two-regime bidimensional Ornstein-Uhlenbeck process with singular diffusion matrix

Ana Prior[1], Paula Milheiro de Oliveira[2]
Instituto Superior de Engenharia de Lisboa e CMUP[1], *Faculdade de Engenharia da Universidade do Porto e CMUP*[2]

In this work we consider a bidimensional Ornstein-Uhlenbeck process assuming two regimes. We assume that the diffusion process switches from one regime to the other at an unknown instant of time. The regimes differ in the value of a parameter appearing in the drift matrix known as the stiffness coefficient that characterizes the model. The stochastic forces acting on the system are assumed to be driven by a Wiener process. The state space model, describing displacements and velocities over time, is assumed to be completely observed and observations are assumed to be taken in discrete times. We describe how to compute the maximum likelihood estimates of the parameters of the stochastic model from the observations, at any given time interval, using all available data, and investigate the problem of detecting the change point. This study includes considering the scenario of a structure that possibly suffers from a loss of stiffness, of unknown amount, after a certain time, and, from the data collected concerning displacements and velocities along the time, one aims at estimating the previous and actual values of the stiffness coefficient. We present a simulation study for a particular real world example that illustrates the procedure and the associated accuracy. The Yuima software is used to simulate the model.

References

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[8] A. PRIOR AND P. MILHEIRO-OLIVEIRA, Asymptotic properties of the MLE of the drift coefficients of a bidimensional Ornstein-Uhlenbeck process with singular diffusion matrix, *Workshop S.A.P.S. IX, LeMans, (poster presentation)* (2013).

[9] A. PRIOR AND P. MILHEIRO-OLIVEIRA, Maximum likelihood estimation of 2n dimension Ornstein-Uhlenbeck processes with singular diffusion matrix: The LAN property, *International conference DYNSTOCH, Copenhagen, (oral and poster presentation)* (2013).

Bayesian inference for discretely observed multi-dimensional diffusion processes

Moritz Schauer, Frank van der Meulen
TU Delft

We consider the problem of Bayesian inference for discretely observed multidimensional diffusion processes using data augmentation.

A main computational difficulty in this approach is the generation of "good" proposals for the unobserved bridge segments connecting the discrete observations to be used in an accept-reject step of a MCMC sampler. A second difficulty is to handle unknown parameters appearing in the diffusion coefficient.

In previous work, proposals for simulating diffusion bridges derived from a linear approximation of the diffusion process were introduced. Superimposing an additional guiding term to the drift of the unconditioned diffusion under consideration resembling a corresponding term in the drift of the true bridge forces the guided process towards the endpoint in the right manner.

In this talk I show how guided proposals are also well suited to address the second difficulty and can be used to update parameters in the diffusion coefficient via a so called innovation process. The procedure extends and unifies previous approaches by Chib et al., Golightly and Wilkinson and others in a continuous time framework.

References

[1] FRANK VAN DER MEULEN, M.S., Bayesian estimation of discretely observed multidimensional diffusion processes using guided proposals, arXiv:1406.4704 (2014).

[2] M.S., FRANK VAN DER MEULEN, HARRY VAN ZANTEN, Guided proposals for simulating multi-dimensional diffusion bridges, arXiv:1311.3606 (2013).

Limit Theorems for Ordinal Pattern Dependence and Their Application to Medical/Biological Data

Alexander Schnurr
TU Dortmund

Continuing the work which we have presented at last years DynStoch meeting, we analyze the dependence structure between stochastic processes from an ordinal viewpoint. In the theoretical part (which is joint work with Herold Dehling) we analyze structural breaks in the dependence structure and derive limit theorems. In the applied part of the talk we study data which has been obtained by analyzing different areas of the kidney. This latter part is joint work with Susanne Ditlevsen.

High-frequency Donsker theorems for Lévy measures

Jakob Söhl
University of Cambridge

Given empirical measures $\mathbb{P}_{\Delta,n}$ arising from increments $(L_{k\Delta} - L_{(k-1)\Delta}) \sim \mathbb{P}_\Delta$, $k = 1, \dots, n$, of a univariate Lévy process sampled discretely at frequency $\Delta \to 0$, we prove Donsker-type functional limit theorems for suitably scaled random measures $(\mathbb{P}_{\Delta,n} - \mathbb{P}_\Delta) * \mathcal{F}^{-1}m$, where $\mathcal{F}^{-1}m$ is a general sequence of approximate identities. Examples include both classical empirical processes ($m = 1$) and a flexible family of smoothed empirical processes. The limiting random variable is Gaussian and can be obtained from the composition of a Brownian motion with time transformation determined through the Lévy measure ν of the process. Two estimation methods for the generalised cumulative distribution function of Lévy measures from high-frequency observations are discussed and both are covered by the Donsker-type theorems. The convolution $\mathbb{P}_\Delta * \mathcal{F}^{-1}m$ is a natural object in the asymptotic identification of ν and appears in both approaches. The first method is a direct estimation method counting the number of increments below a certain threshold, where increments near zero are downweighted to take account of the possible infinte jump activity. The second estimation method relies on an identification via the second derivative of the Lévy-Khintchine representation.

Applications of our results include confidence bands and a Kolmogorov-Smirnov test for Lévy measures.

References

[1] R.NICKL, M. REISS, J. SÖHL AND M. TRABS, High-frequency Donsker theorems for Lévy measures, *arxiv:1310.2523* (2013).

Markov switching models for high-frequency time series from automatic monitoring of animals

Luigi Spezia[1], Cecilia Pinto[2]
Biomathematics & Statistics Scotland (BioSS)[1], *University of Aberdeen*[2]

In ecological studies data loggers can be applied to mammals, fishes, and birds to automatically monitor the movements of animals to study their behaviour. Sensors applied to animals generate high-frequency complex time series that are modelled along with environmental dynamic variables. Animal movement time series usually exhibit high autocorrelations at the higher lags, with a slow decay, and asymmetric cycles. Both issues suggest to handle the series as realizations of a stochastic regime switching process. Hence, Markov switching autoregressive models (MSARMs) can be considered. Covariates can also be incorporated into the model through the hidden Markov chain: the transition probabilities are time-varying and dependent on dynamic explanatory variables.

Our modelling is motivated by a real application: the time series of depth profiles recorded by Data Storage Tags applied to flapper skates (Dipturus intermedia) caught in the Sound of Jura (Scotland) in 2012. Inference is developed under the Bayesian paradigm by Markov chain Monte Carlo (MCMC) algorithms. We demonstrate that MSARMs are very good tools to fit the long memory, non-linear, non-Normal, non-stationary processes of depth profiles, and to cluster the observations into regimes of movement. New methodological contributions have been also developed: i) the hidden Markov chain is assumed to be non-homogeneous, with multiple transition matrices alternating according to the dynamics of some categorical covariates; ii) the identifiability of the model is solved without placing any constraint, but by an automatic reordering of the draws obtained at each sweep of the MCMC algorithm.

Adaptive confidence bands for drift estimation of diffusions

Mathias Trabs[1], Jakob Söhl[2]
Humboldt-Universität zu Berlin[1], *University of Cambridge* [2]

The nonparametric estimation of the unknown drift b of a diffusion is studied, given discrete observations of the process with fixed observation distance. Uniform central limit theorems are proved for wavelet projection estimators of the invariant measure as well as of the drift in a multi-scale space. Applying Lepski's approach, we construct adaptive confidence sets for a data-driven version of the drift estimator. The L^∞- diameter of this confidence band is (almost) of the order of the minimax convergence rate for estimating b. The proofs rely on a non-standard concentration inequality which is due to the Markovian structure of the observations.

Hybrid multi-step estimators for stochastic differential equations from discrete observations

Masayuki Uchida
Osaka University

We deal with the estimation problems for both volatility and drift parameters of a d-dimensional ergodic diffusion process defined by the following stochastic differential equation $dX_t = b(X_t, \beta)dt + a(X_t, \alpha)dw_t, X_0 = x_0$, where w is an r-dimensional standard Wiener process, x_0 is a deterministic initial condition and $\theta = (\alpha, \beta) \in \Theta_1 \times \Theta_2 = \Theta$ with Θ_1 and Θ_2 being compact convex subsets of $\mathbf{R}^{m_1}$ and $\mathbf{R}^{m_2}$, respectively. Moreover, $a : \mathbf{R}^d \times \Theta_1 \to \mathbf{R}^d \otimes \mathbf{R}^r$ and $b : \mathbf{R}^d \times \Theta_2 \to \mathbf{R}^d$. $\theta^* = (\alpha^*, \beta^*)$ is the true value of θ. We assume that $\theta^* \in \mathrm{Int}(\Theta)$ and the parameter spaces have locally Lipschitz boundaries. The data are discrete observations $\mathbf{X}_n = (X_{t_i^n})_{0 \le i \le n}$, where $t_i^n = ih_n$. Let p be an integer value and $p \ge 3$. We will consider the situation when $h_n \to 0$ and $nh_n^p \to 0$ as $n \to \infty$, and there exists $\epsilon_0 \in (0, (p-1)/p)$ such that $n^{\epsilon_0} \le nh_n$ for large n. In this talk, we propose the hybrid multi-step estimators, which are derived as follows. We first obtain the initial Bayes type estimators $\tilde{\alpha}_n^{(0)}$ and $\tilde{\beta}_n^{(0)}$ satisfying that $n^{1/p}(\tilde{\alpha}_n^{(0)} - \alpha^*) = O_p(1)$ and $(nh_n)^{1/(p-1)}(\tilde{\beta}_n^{(0)} - \beta^*) = O_p(1)$. Next we get multi-step estimators by means of the Newton-Raphson method with efficient quasi-likelihood functions. It is shown that the proposed estimators have asymptotic normality and convergence of moments. Moreover, we give an example and simulation results of the hybrid multi-step estimators.

Edgeworth expansion for the pre-averaging estimator

Bezirgen Veliyev
Aarhus University

We present the Edgeworth expansion for a pre-averaging estimator of quadratic variation in the framework of continuous diffusion models observed with noise. More specifically, we derive a second order expansion for the joint density of the estimators of quadratic variation and its asymptotic variance. The methodology relies on martingale embedding, Malliavin calculus and stable central limit theorems for continuous diffusions. Finally, we demonstrate the density expansion for the studentized statistic, which might be applied to construct asymptotic confidence regions.

Parametric estimation problem for a time-periodic signal with additive periodic noise

Khalil El Waled
Université de Rennes

The main goal of this work is the drift estimation of a signal plus noise model given by the following equation $d\zeta_t = f(\theta, t)dt + \sigma(t)dW_t$, where the functions $f(\cdot, \cdot)$, $\sigma(\cdot)$ are continuous and periodic in t, W_t is a Brownian motion, θ is an unknown parameter; $\theta \in \mathbb{R}$.

Firstly, we study this estimation from a continuous time observed throughout the interval $[0, T]$. Using the maximum likelihood method we build an estimator $\hat{\theta}_T$ of θ and we establish its consistency. In the particular case when $f(\theta, t) = \theta f(t)$, the expression of $\hat{\theta}_T$ is explicit and we have the strong consistency and the asymptotic normality as well as the asymptotic efficiency when $T \to \infty$.

Secondly, from a discrete observation, we study the maximum contrast estimator and we establish its convergence in probability $\P_\theta$.

We look also more precisely at the case when $f(\theta, t) = \theta f(t)$, and then we propose an estimator of θ and we show the mean square convergence and the asymptotic normality property of this estimator.

Testing for jumps in stochastic volatility models

Jeannette Woerner, Christian Palmes
TU Dortmund

Recently jump tests in continuous-time financial models, especially stochastic volatility models, have attained much interest, since they provide an important tool for models selection and influence other statistical procedures such as estimation of the volatility.

We will mainly focus on the Gumbel test, a method based on extreme value theory, which in contrast to many other methods provides a a test for positive and negative jumps separately. We discuss the conditions which have to be imposed on the volatility process, e.g. a certain degree of Hölder continuity or the size of jumps. Furthermore, we compare the Gumbel test to the classical test of Barndorff-Nielsen and Shephard based on bipower variation and see that the Gumbel test possesses more power.

Volatility model selection

Nakahiro Yoshida
University of Tokyo

Stochastic differential equations are used for modeling various structures of volatility. Then model selection is a basic problem to develop data analysis. In this talk, we present a spot volatility information criterion sVIC for volatility model selection. As in classical mathematical statistics, inferential statistical methods give an approach to this question for dependent data. However, statistics is non-ergodic when observations are sampled discretely under finite time horizon. Construction of the information criterion is not straightforward due to non-ergodicity. New machineries are the quasi likelihood analysis for volatility (SPA 2013 with M. Uchida), the martingale expansion in mixed normal limit (SPA 2013), and asymptotic expansion for the QMLE.

Variational Bayesian inference method in stochastic modelling of subcutaneous glucose concentration

Yan Zhang
University of Warwick

Diabetes is a lifelong condition in which the body cannot control blood glucose. Patients living with diabetes must learn to control blood glucose levels to avoid life- threatening situations. Researchers have been working on establishing an effective dynamic model to describe and predict blood glucose concentration levels for more than half a century. Many models have been developed to reflect the complex neuro- hormonal control system, but one of the major challenges remains is how to determine large amounts of parameters in these models while only the glucose concentration time series is provided.

We used a top-down data driven approach to establish a stochastic nonlinear model with minimal order and minimal number of parameters tailored for each patient to describe and predict the response of blood glucose concentration to food intake. Various degrees of nonlinearities are considered for three groups of people (the control group, Type I diabetes and Type II diabetes group). Variational Bayesian method is applied to select the best model and infer the needed parameters. The parameters describe the dynamics and characteristics of the underlying physiological processes. Since the mechanisms of the glucose absorption are different for Type I, Type II diabetes and non-diabetic people, different distributions of parameters and noises for these groups are expected.

The results from fifteen profiles with 72 hour continuous glucose time series shows that the glucose concentration change during 2 hours after food intake can be modelled by second order linear or nonlinear system for all three groups. The value of the parameters and intensities of the noises vary from peak to peak for a single profile. The analysis of variance for parameters and noise intensities shows significant differences between the control group and both diabetes group. Further comparison with existing models is going to be investigated in the near future.

5 Poster Abstracts

Reconstruction Algorithm for Branching Diffusions with Immigration

Tobias Berg
Johannes Gutenberg-Universität Mainz

We consider finite systems of branching particles where the particles move independently according to one-dimensional diffusions. Particles are killed at a position-dependent rate and leave a random number of offspring being located according to some transition kernel. In addition, new particles immigrate at some position-dependent rate. A process with these properties is called a branching diffusion with immigration (BDI). Observing the path of a BDI only at a regular grid of time, we present an algorithm for reconstructing the path of the BDI.

Approximately optimal importance sampling for Lambda-coalescents

Jere Koskela
University of Warwick

The Lambda-Fleming-Viot process is a measure-valued jump diffusion which models the allele frequencies of large populations of individuals with infinite variance family size distribution. The likelihood of a sample of alleles is given by the stationary moments of the process, which are intractable in nearly all cases of interest. A well- known duality relation with the Lambda-coalescent, which models the ancestral tree of alleles sampled from the Lambda-Fleming-Viot process, can be used to obtain importance sampling approximations. I will show how time-reversal of the Lambda- coalescent yields a formula for the optimal proposal distribution, which is as intractable as the likelihood but can itself be approximated in a principled way. Numerical tests show these approximations yield efficient importance sampling algorithms.

Adaptive deconvolution on the nonnegative real line

Gwennaëlle Mabon
CREST-ENSAE & MAP5

We consider the problem of adaptive estimation of nonnegative variables on the real line in an additive model defined by $Z = X + Y$ with X independent of Y. We assume that we observe n copies of X and Y.

We want to recover the distribution of X through the observations Z assuming that the distribution of Y is perfectly known. This issue can be seen as the classical statistical problem of deconvolution which has been tackled in many cases. Nonetheless, in the present case the random variables have the particularity to be $\mathbb{R}_+$ supported. Knowing that, we propose a new angle of attack by building a projection estimation method with an appropriate Laguerre basis. We then propose a nonparametric adaptive strategy to estimate the density and survival function of X. In the density estimation case, we also propose an adaptive procedure of the forward problem. We present upper bounds of the $\mathbb{L}^2$ integrated risk along. The procedures are illustrated with simulated data and compared to the performances in a more classical deconvolution setting using a Fourier approach.

Change-Point Detection in Parametric Stochastic Models

Fanni Nedényi
University of Szeged

A change in the dynamics of a stochastic process means a disturbance in the underlying model, therefore it is important to detect such changes as fast as possible. This problem has been the subject of intense investigation in the recent years for both parametric and non-parametric models. On our poster online procedures are presented to detect these changes. For the sake of applicability we define tests in open-end and also in closed-end forms meaning that the time horizon of the sampling is infinite and finite, respectively. Applying a suitable parameterization of the model, our goal is to detect the change of the parameters. The methods are based on sequences of martingale differences related to discrete time observations of the underlying process. We consider CUSUM-type test statistics using the cumulated sums of the estimators of these martingale differences. To illustrate the method, we examine the three following discrete time models: linear regression models, AR(1) processes, and multitype Galton–Watson processes. Simulation results for the last model are also available. Depending on the current status of the ongoing research, application of the method to continuous time diffusion processes, such as the CIR and the Heston models, may also be discussed.

Exact Simulation in a Nutshell

Murray Pollock, Adam Johansen, Gareth Roberts
University of Warwick

In this poster we will discuss recent work extending methodology for simulating finite dimensional representations of jump diffusion sample paths over finite intervals, without discretisation error (exactly), in such a way that the sample path can be restored at any finite collection of time points. We demonstrate the efficacy of our approach by showing that with finite computation it is possible to determine whether or not sample paths cross various non-standard barriers.

U- and V-statistics for Ito Semimartingales

Christian Schmidt
Aarhus University

We study the asymptotic theory for U- and V-statistics of high frequency observations of Ito semimartingales of the form

$$X_t = x + \int_0^t a_s ds + \int_0^t \sigma_s dW_s + J_t, \quad t \in [0,T].$$

In the case of a vanishing jump part J_t, we prove, based on empirical process methods, uniform convergence in probability and show a functional stable central limit theorem for the standardized version of a U-statistic of some order d, i.e. for

$$U(H)_t^n = \binom{n}{d}^{-1} \sum_{1 \le i_1 < \cdots < i_d \le \lfloor nt \rfloor} H(\sqrt{n}\Delta_{i_1}^n X, \ldots, \sqrt{n}\Delta_{i_d}^n X), \quad (\Delta_i^n X = X_{\frac{i}{n}} - X_{\frac{i-1}{n}}).$$

If jumps are included, we consider V-statistics

$$V(H)_t^n = n^{-\alpha} \sum_{1 \le i_1, \ldots, i_d \le \lfloor nt \rfloor} H(\Delta_{i_1}^n X, \ldots, \Delta_{i_d}^n X).$$

and provide a law of large numbers and a central limit theorem. In this case the type of the limit (and even the convergence rate) heavily depend on the choice of the kernel function H.

6 Participant List

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Continued on next page

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Delegate Joining Instructions
Warwick Conferences' Conference Park

We are delighted that you will be joining us at the University of Warwick. We hope that the information provided in this document will help you get the most from your event. Please bring these instructions with you as you will find them useful whilst you are on campus.

The Conference Park is on the main campus of the University of Warwick located on the outskirts of Coventry, which is accessible by road, rail and air. You can download further information from the website at www.warwickconferences.com, following the link 'how to find us'. A further link can be found for any relevant traffic information
http://www.warwickconferences.com/delegates/delegates-conference-park

The Conference Park is the name given to the facilities provided by Warwick Conferences on the main University campus.

Getting here:

University and local roadworks 2014

- The University in conjunction with the local areas are working on a major development to improve the roads in and around the University.
- Specifically aiming to improve the safety and capacity of our roads and the appearance and accessibility of major areas of campus.
- This all starts this summer with major changes to Gibbet Hill Road, starting on 23 June 2014 and due to end in October 2014, with sections of the road closed at times.
- We recommend that you allow approximately an additional 30 minutes for your journey (and more at standard rush hour times) as there may well be congestion around campus. On approach to campus, please be aware of diversion signage and follow as directed.
- Once you're on campus, please pay close attention to signage – diversions and traffic management will change on a daily basis depending on what work is being carried out - staff will be located at car parks and other key areas to assist and advise.

Which direction to approach from:

- For the Conference Park please head for Westwood Heath/Kirby Corner Road. If your journey currently brings you along the A46 then you will need to carry along onto the A45 (there will be diversion signs to the A45).

Where to park:

If you're arriving at Central Campus including:

- Conference Park Reception
- Rootes Building
- Warwick Arts Centre
- Ramphal Building

Please use car parks 7, 8, 8a and 15

Car parking:

Once you arrive on campus please look out for the blue Warwick Conferences signage to direct you to the car parks and conference venues.
Complimentary car parking is available for conference delegates in the allocated car parks on campus (7, 8, 8a and 15). On entering the car park, you will be provided with a pass for these car parks and this should be placed in the window of your vehicle, if arriving after 19.00hrs and some weekends it may be necessary for you to collect a pass from the Conference Reception in the Student Union Building.
Disabled parking spaces are available close to the entrance of main buildings.

As a University campus, from time to time these car parks become full and when this happens alternative parking will be available, which you will be directed to. We advise that you allow sufficient time, for up to a ten minute walk to get to your destination on the Conference Park from the car parks. Some of the car parks are not adjacent to the registration and accommodation areas, it is therefore advisable once you have parked, for you to take your luggage to Conference Reception where you will be able to leave it with the team in the left luggage facility.
Your Event Organiser can provide further information regarding car parking arrangements.

Accommodation:

Please check with your Event Organiser as to which type of accommodation has been reserved for your event and what facilities are available.

Conference Reception:

Located within the Students Union Building. The Reception team are available to answer your queries between 07:00 – 23:00. Here you can also:

- Find out general information
- Arrange for secure luggage storage
- Validate your car parking token
- Collect information on how to connect to the wifi around campus
- Ask about any lost property
- Request additional bedroom supplies such as pillows, blankets, clock radio, bath mat or a bedside lamp

Keys:

You will be provided with one key or key card which will access your room and entry door to the residence. Keys can be left at Conference Reception, Rootes Restaurant (in Rootes Building) or one of the boxes situated in the entrance halls of each residence on the day of your departure.

Bedroom check in/out:

Bedroom keys will be available from 15:00 to 23:00 at Conference Reception. If you plan to arrive after 22.45, please contact Conference Reception to arrange late key collection (wcpreception@warwick.ac.uk). Rooms need to be vacated by 09:30 on your day of departure and all luggage and belongings to be removed at that time. Please inform Conference Reception on arrival, of any difficulties you may have in the unlikely event of an evacuation from your accommodation (e.g. hearing or mobility difficulties).

Disability services:

The University of Warwick aims to be accessible and welcoming to everyone and we are committed to making your visit as easy and enjoyable as possible. If you have any particular requirements that we should be aware of, hen please discuss these with your Event Organiser.

Internet access across campus:

If you would like to access the wifi network then please ask at Conference Reception or any of the Information Points around campus (e.g. Rootes Building and Warwick Arts Centre) for details. Alternatively log onto your device and go to your web / wireless browser:

1. Connect your device to the **'Warwick Guest'** wireless network.
2. Upon your first attempt to access online content with the web browser, you will be redirected to the Warwick Guest Wireless web page (most Apple devices will automatically perform this step).
3. If you already have a valid Warwick Guest account, please login with those credentials, otherwise please continue to create yourself a Warwick Guest account. N.B. This is **NOT** the same account used on the 'conferences' wireless network.
4. Click the link within the sentence 'Click here to create an account' and select 'Attending a conference'.
5. Please provide your details, including a valid mobile phone number, to which you generated guest login will be sent.
6. Follow the web links to return to the Warwick Guest Wireless webpage and login.
7. If you do not have a mobile phone, choose the option 'Click here to register if you do not have a mobile phone' at the bottom of the page to have your login details sent to your email address.

Food and Drink:

All meals are provided in Rootes Restaurant located on the first floor of Rootes Building for all delegates (unless your programme indicates otherwise). The restaurant offers an assisted style service of breakfast, lunch and dinner including a range of hot and cold drinks. Your Event Organiser will be able to advise you regarding the specific arrangements for your event. Please have with you your conference badge or room key to gain access to the restaurant. If you have any special dietary requirements then please inform your Event Organiser.

The bar is located on the first floor of Rootes Building and is the ideal place to network and relax after a day's session. There are also alternative bars in Warwick Arts Centre and Students Union building (check opening times locally)
Payment for all sundry items is by cash or credit card payment only.

Shops, Banks, Cafés and Bars on campus:

The campus has many facilities available to all delegates, for all information and opening times please see the website: http://www.warwickretail.com . Warwick Arts Centre cinema offer discounted cinema tickets at £5.50, these can be purchased from the box office and proof of delegate status is required (not applicable for Met Opera Live or NT Live screening).

Sports facilities:

Delegates have use of some of the comprehensive sports facilities including swimming and fitness suite free of charge. Other facilities are available for a nominal charge which will need to be booked in advance. Details and opening times are available at Reception or by visiting the website below. Delegates need to present their bedroom key at the reception to gain access. See www2.warwick.ac.uk/services/sport for more information.

For more information:

You can also refer to our Frequently Asked Questions document (FAQ's) which can be obtained from your Event Organiser or our website: http://www.warwickconferences.com/delegates/delegates-conference-park

Frequently Asked Questions
Warwick Conferences' Conference Park

Location and travel

Where in Coventry is the University of Warwick?
Just four miles from Coventry City centre, we are sited at the hub of the central motorway network.

What is the Conference Park?
This is the name given to the facilities provided by Warwick Conferences on the main University campus. The building used for dining and bars is Rootes Building and Conferences Reception is within the Students Union Building.
A link can be found for all relevant traffic information at: http://www.warwickconferences.com/delegates/delegates-conference-park

Once you arrive on campus please look out for the blue Warwick Conferences signage to direct you to the car parks and conference venues.

Where is the nearest Mainline Rail Station?
Coventry Intercity station is only four miles from the University. A taxi would cost approximately £11.00 from Coventry station to the University campus. Birmingham International Railway Station is also close to campus and a taxi from this location would cost approximately £27.00.

Is there a taxi rank on campus?
Taxis are available on Health Centre Road opposite Warwick Arts Centre at most times of the day. Alternatively you can contact Conference Reception for more information and relevant phone numbers.

Can I travel by bus from Coventry Railway Station or Bus Station?
The Number 12 bus runs from Coventry Bus Station via Coventry Train Station to the University

Is car parking free or do you have to pay?
The Conference Park offers limited complimentary parking in specified car parks. You will need to validate your parking token at Conference Reception. Your Event Organiser will be able to advise you further.

If I have a minibus or high sided vehicle – where can these be parked?
Minibuses and high sided vehicles can park on the ground floor (outside section) of Car Park 15. It would be advisable to let your Event Organiser know of your requirement for specific car parking, as most of the University car parks are multi storey.

Accommodation

What time can I collect my bedroom key?
Check in for the Conference Park is from 15:00 onwards. Keys are collected from Conference Reception, unless you have been notified of a different location by your Event Organiser.

What will happen if I arrive after 22.45 and Conference Reception is closed?
Conference Reception is open until 23:00. If you are planning to arrive later than 22.45, please call in advance on 02476 528910 to arrange key collection from an alternative location. Once Reception is closed there is clear signage on the main door explaining the process for late arrivals.

Will we stay in halls of residence?
All Conference Park accommodation is student style either a standard or en-suite room. Your Event Organiser will be able to advise you on which type of accommodation you have been allocated.

Do any of the residences have lifts?
Some residences do. If you have a particular requirement then please discuss with your Event Organiser.

What time do I need to check out of my room?
Check out time is 09:30 and all luggage and belongings should be removed at that time.

What electrical supply is available in the bedrooms?
Electricity is supplied at 220/240v and 50 cycles AC. Most foreign appliances will require an adaptor or transformer. Adaptors are available to buy at Costcutter supermarket.

Are there any laundry facilities on campus?
The launderette is situated between Rootes Building and Rootes residences, opening times are available from Conference Reception for self-service washing and drying. There are also laundry facilities available in some of the residences. All machines require the correct change and you will need to provide your own washing powder and fabric softener.

Will I have access to a kitchen within my accommodation block?
Each delegate will have access to a kitchen although this may not be directly adjacent to their bedrooms. Please note these areas will not contain any cooking equipment or utensils.

Facilities on campus

What Leisure facilities are there and do delegates have access?
Delegates may use some of the University's Leisure facilities free of charge providing they take along their bedroom key or delegate name badge as a means of identification. Other facilities are available for a nominal charge and may need to be booked in advance. The towel from your bedroom can be taken to the Sports Centre, alternatively you can hire an additional towel at the Sports Centre for £1.75. Please see http://www2.warwick.ac.uk/services/sportscentre for further details.

What religious services are available on campus?
The Chaplaincy is a vibrant space for all members of the University community and visitors. To gain access to the Chaplaincy, please ask at Conference Reception for details.

Are there any cash machines or banks on campus?
There are branches of Barclays and Santander, both have cash machines in the Students Union Building (directly next to Rootes Building).

Where can I access my emails?
Conference Park delegates can access the wifi network around campus and within their accommodation block, please ask at Conference Reception or any member of the team for the details of how to connect. A limited number of computers are available for delegate use in the Conference Reception.

If I am having mobility problems is there anything you can do to help?
Mobility scooters are available for conference delegates; please ask at Reception for more information.

What should I do if I am not feeling well?
Please contact Conference Reception on 02476 522280, who will ensure a message is given to your Event Organiser. We do not have a resident doctor available for conference delegates, but in the event you require medical attention, this can be done via our 24 hour Security Team on 02476 522083. Alternatively there is a Walk In Medical Centre in Coventry - click here for more details.

Is there anywhere on campus I can buy toiletries or get pharmacist advice?
There is a pharmacy located in the Students Union Building and Costcutter supermarket also sells a variety of items. These buildings are located next to Rootes Building.

Food and drink on campus

I have a particular special dietary need – can you manage this?
The Conference Park Team can manage all special dietary needs if they are aware of the requirement in advance. Please ensure you communicate this to your Event Organiser before arriving at Warwick. Once on campus, please ask any of the team in the restaurant for more information or guidance.

Where can I purchase alcohol on campus?
There are three licensed buildings where you can purchase alcohol for consumption within or outside of that building. These are:

- Rootes Building
- Warwick Arts Centre
- Students Union Building
- Costcutter is also a licensed retail shop, however alcohol purchased from Costcutter cannot be consumed in any of the above licensed areas.

Local Area

What is there to do in the local area?
There is a wide range of social and sports facilities available on campus, including woodland walks, a sports hall, swimming pool and squash courts. The largest Arts Centre outside of London - Warwick Arts Centre is also onsite where you can watch the latest cinema releases and/or performances. Coventry city centre is only three miles away and the towns of Warwick, Stratford Upon Avon and Leamington are close by.

Where are the nearest shops to campus?
There are a number of retail shops on campus including Costcutter supermarket, Pharmacy, Bookshop and Hairdressers, for any other requirements there is:

- Cannon Park Shopping Centre is within ten minutes walk and has a large supermarket and several smaller retail shops
- Central Six Retail Park is a ten minute car journey (next to Coventry Railway Station) and has a large chemist and some good sized high street stores

Other useful information

What signage should I look out for on campus?
University Signage – these are positioned around campus highlighting all Academic Buildings and social spaces – they are white rectangular blocks

Warwick Conferences / Conference Park signage – these are blue swing signs used to highlight car parking spaces and spaces used for conferences. Look out for the conference logo.

Are there any other useful items I could bring with me?

- An umbrella – as you will be required to walk between some buildings
- Any sports equipment that you may require during your stay
- Additional towels for use in the Sports Centre
- Suitable clothing and footwear
- Phone charger

Opening times

Summer vacation: Saturday 28 June – Saturday 28 September 2014

Café Library
Monday – Friday 8am – 4pm*
Saturday – Sunday 10am – 4pm
* The extension will be open 8am – 6pm

Café Humanities
Monday – Friday 8.30am – 3pm

Le Gusta
Monday – Friday 12pm – 10pm**
Saturday – Sunday 5pm – 9pm

University House restaurant
Monday – Friday 8am – 2.30pm

University House atrium coffee bar
Monday – Friday 8am – 6pm

Fusion
Monday – Saturday 12pm – 3pm

Costa
Monday – Friday 8am – 5pm
Saturday – Sunday 9am – 4pm

The Bookshop
Monday – Friday 9am – 5.30pm

Warwick Business School
Monday – Friday 8.30am – 3pm

"Belle" on the piazza
Lunch and Evening
(see local advertising and twitter)

Library Coffee Bar
Monday – Friday 8.30am – 4pm

Café Social (closed August)
Monday – Friday 9.00am – 2.00pm

Café Gibbet Hill
Monday – Friday 8am – 4.30pm

Café Bar
Monday – Saturday 8am – 9pm
Sunday 3pm – 8.30pm

Theatre Bar
Dependent upon performances

The Bar (serving bar food)
Monday – Sunday 12 noon – 11pm

Costcutter
Monday – Friday 8am – 8pm
Saturday 9am – 8pm
Sunday 11am – 5pm

Café Westwood
Monday – Friday 8am – 3pm

H-van (behind WMG building)
Monday – Friday 9am – 3pm

** Last food orders 9pm. Please note that in exceptional circumstances management reserve the right to change opening times without prior notice.