UNIVERSITY OF KENT
Faculty of Science, Technology and Medical Studies
SCHOOL OF MATHEMATICS, STATISTICS AND ACTUARIAL SCIENCE

MATHEMATICS AND STATISTICS 2009 / 2010

UNDERGRADUATE DISSERTATIONS / PROJECTS FOR THIRD–YEAR STUDENTS (MA600)

IMPORTANT: PLEASE READ THE FOLLOWING INTRODUCTORY REMARKS

The dissertation and project topics listed below are being offered this year by the academic members of the Mathematics and Statistics staff. Students interested in a topic should contact the staff member concerned. Students may, of course, want to investigate several topics before deciding on the one for their dissertation. Students may also want to propose their own topics, and this is possible provided that they can find a member of staff who is willing to supervise their chosen topic. It may be possible for more than one student to choose a topic with the same *general* heading, provided that the projects undertaken by different students are sufficiently different in the specifics.

Not all topics are suitable for all students. Some may require that you have passed or are attending certain modules, or obtained a particular Stage 2 mark.

Arranging a topic with a particular supervisor can take some time, therefore requests for topics which are made immediately before the deadline for registration may not be accepted.

Members of staff are likely to impose a limit on the number of dissertations which each individual is able to supervise. A dissertation supervisor will therefore not necessarily be the member of staff who proposed the dissertation and the choice of available topics will decrease as time passes.

NEW FOR 2009-2010:

Topics can be approved at any time up to the last day of Week 5, Friday 30th October, 2009. There is a topic approval form which needs to be signed both by you and the supervisor and then given to the module convener, Prof Elizabeth Mansfield.

The Key Skills seminars will run in Weeks 2-6, and LaTeX classes in Weeks 7-10. The Key Skills and LaTeX component of the final mark is 10%.

The deadline for submitting the outline and management plan of the dissertation/project is 12.00pm on the last day of Week 8, Friday, 20th November, 2009, but can be submitted earlier. Feedback on the plan will be given. Help with writing the project plan will be given in the Key Skills seminars. Your project management will count towards the final mark.

Dissertations/Projects must be handed into the General Office Reception (Room E01) by 12.00 p.m. on the last day of the Spring Term, **Friday 9th April 2010.**

MATHEMATICS TOPICS

PROFESSOR PA CLARKSON

1. Special Functions and Orthogonal Polynomials.
Texts:
"*Special functions*" by G. Andrews, R. Askey and R. Roy.
"*Special functions of mathematical physics and chemistry*" by I. Sneddon.

2. Solitons.
Texts:
"*Solitons: an Introduction*" by P.G. Drazin and R.S. Johnson.
"*Solitons, nonlinear evolution equations and inverse scattering*" by M.J. Ablowitz and P.A. Clarkson.

DR TC DUNNING

1. Alternating sign matrices
An alternating sign matrix (ASM) is a matrix with entries -1, 0 and 1 such that each row and each column sums to 1, and the non zero entries alternate in sign. The number of ASM's of size n with a 1 as the first and last non zero entry in each row/column form the famous sequence

1,2,7,42,429,7436, 218348,10850216,911835460,...

Possible projects include the history of the recently-proved ASM conjecture or ASMs in mathematical physics. Some investigations using Maple will be required. See Dr A Hone's article `Dodgson condensation, alternating signs and square ice' Phil. Trans. R. Soc. A (2006) 364, 3183.

2. Applications of Lagrangian Mechanics in two or more dimensions
Many problems in mechanics are easier to deal with in the framework of Lagrangian mechanics rather than Newtonian mechanics. This project applies the theory of Lagrangian Mechanics to various situations in two or more dimensions (vibrational modes of molecules, behaviour of a spinning top or a guitar string etc). Some Maple work will be required. You should have obtained a good mark in MA590 and it would help if you also take MA563 Calculus of Variations.

PROFESSOR P FLEISCHMANN

1. **Knot Theory**:
   - invariants of knots;
   - algebraic methods;
   - diagram methods;
   - knot polynomials;

Literature:
Louis H. Kauffman, *On Knots*, Princeton University Press, 1987.
C. Livingston, Knot Theory, *Carus Mathematical Monographs* 24.
K. Murasugi, *Knot Theory and its Applications*, Birkhaeuser, 1996.
Current research articles and preprints.

2. **Symmetries and finite groups**:
   - Group actions, stabilizers, orbits;
   - Burnside's lemma;

– Polya enumeration;

Literature:

M. Aschbacher, *Finite group theory*, Cambridge studies 10.

Peter J. Cameron, *Permutation Groups*, Cambridge University Press.

A. Kerber, *Applied finite group actions*, Springer, 1999.

3. Finite fields and their applications:

- new algorithms of polynomial factorization;
- selected topics in coding theory;
- multiplication algorithms and VLSI - hardware design.

Literature:

Lidl, Niederreiter, *Introduction to Finite Fields and their Applications*, Cambridge University Press (1986).

Jungnickel, *Finite Fields*, BI Wissenschaftsverlag, Mannheim (1993).

DR ANW HONE

1. Reaction-diffusion models and nonlinear waves in cell biology:

For linear systems (ODEs, PDEs or difference equations), the behaviour can be described exactly by standard techniques (as in 1st year MA302 Mathematical Methods, or 2nd year MA588 Mathematical Techniques &Differential Equations). However, most nonlinear systems cannot be solved exactly, and the solutions can only be understood using qualitative methods, or numerically. This dissertation will explore the behaviour of nonlinear waves that arise in PDE models of biochemical reactions inside cells. The PDEs used are called reaction-diffusion equations, and will be explored using analytical and numerical methods (with Maple).

This project would be most suitable for students taking MA591 Nonlinear Systems and Mathematical Biology.

Recommended text: Computational Cell Biology, C.P. Fall et al. (Eds.), Springer (2002).

2. Analytic number theory:

If a number *p* is prime, then what is the next largest prime number? This question doesn't have an easy answer - in some sense the prime numbers appear "at random". However, this randomness can be quantified very precisely: the prime number theorem says that the number of primes less than n grows like n/log(n). This project will explore how the distribution of the prime numbers can be described analytically, using the theory of functions - in particular, the Riemann zeta function. To begin with, this will mainly be approached via real variable calculus, but the course MA572 Complex Analysis will be helpful at a later stage.

This project would be most suitable for students taking MA572 Complex Analysis.

Recommended text: A Primer of Analytic Number Theory, J. Stopple, Cambridge (2003).

3. Theory and applications of quantum mechanics:

The laws of classical physics cease to hold when one considers matter at the microscopic scale. The position and momentum of a subatomic particle cannot be known simultaneously, in principle, in the quantum world. The project will explore the mathematical formalism of quantum mechanics in the Schrodinger picture (wave mechanics), as well as applications in current technology such as lasers, Josephson junctions and nanomotors.

Prerequisite: MA588 Mathematical Techniques &Differential Equations.

Recommended text: An Introduction to Quantum Theory, K.C. Hannabuss, Oxford (1997).

DR S KRUSCH

1. Topological Solitons

A soliton is a physical object which behaves like an extended particle. The first solitons to be discovered were waves travelling along canals, keeping their form over remarkably long distances. Topological solitions have the special property that they are stable in the sense that the total number of solitons of a given field configuration is always constant in time. These solitons occur in various areas of physics (condensed matter physics, nuclear physics, cosmology), examples are kinks, lumps, vortices, monopoles and skyrmions.

Possible projects include
(a) studying the dynamics of solitons using numerical methods
(b) studying analytic approximations to the dynamics of solitons
Literature:
Nicholas Manton and Paul Sutcliffe, "Topological Solitons", Cambridge University Press (2004)

2. Numerical methods which preserve geometric properties.

One measure of how good a numerical scheme is, is the numerical error. In this project we discover other properties which can be just as important for the quality of the solution. This project involves a theoretical study as well as some MatLab programming. You must be registered for MA587 Numerical Solutions of Differential Equations and have a Stage 2 average of at least 65%.
Literature:
Simulating Hamiltonian Dynamics, Leimkuhler and Reich, Cambridge University Press, 2005.
Geometric Numerical Integration, Hairer and Lubich and Wanner, second edition, Springer Verlag, 2006.
Geometric Integration and Its Applications, Handbook of Numerical Analysis, Volume XI North-Holland 2000.

DR S LAUNOIS

If you want to have a more accurate idea of the different projects, or if you already have a topic in mind, please do not hesitate to come to me!

1. Totally non-negative matrices.

Totally non-negative matrices are matrices whose entries and minors are all non-negative. They have appeared in different part of sciences such that biology and economics. In this project, we will investigate the properties of these matrices and study different algorithms to construct them.
Text: "Matrix Theory" by Gantmacher

2. Examples of non-commutative algebras

Non-commutative phenomena are perhaps as old as mathematics itself; they manifest themselves in the simplest mathematical objects, such as permutations or matrices. In this project, we will study two of the most important non-commutative algebras: the Weyl algebra and the quantum plane. As an application, we will generalise the well-known binomial formula.
Texts: "A primer of Algebraic D-modules" by Coutinho and "Quantum Calculus" by Kac and Cheung

3. Around Rogers-Ramanujan identities

The theory of partitions have attracted a number of great mathematicians. In this project, we will look at beautiful identities that were obtained by Rogers-Ramanujan.
Text: "Integer partitions" by Andrews and Eriksson.

4. Quivers

The theory of representations is a fundamental concept in Mathematics with many applications. This dissertation will explore the representation theory of quivers by using (non trivial) linear algebra tools. Text: Lecture notes by H. Derksen (available on the web)

DR BAS LEMMENS

1. Tropical mathematics. Suppose that we replace addition by taking maximum and multiplication by taking the sum, so $3 \oplus 2 = 3$ and $3 \otimes 2 = 5$. In this way we obtain a new algebra, which is known as the max-plus or tropical algebra. The origins of this algebra lie in optimisation and scheduling theory, and have recently found surprising applications in algebraic geometry. In this project we will study this algebra and its applications. This is a relatively new field in mathematics and probably requires reading original research papers. However, the following book is a good start:
Max Plus at Work, Princeton Series in Applied Mathematics, by Bernd Heidergott, Geert Jan Olsder, Jacob van der Woude, 2006.

2. Hilbert's geometries. Hilbert's geometries were introduced by Hilbert in a letter to Klein, and are a natural generalisation of hyperbolic geometry. They embody geometrically diverse structures and have striking applications in analysis. In this project we will study some recent results and, possibly, open problems concerning Hilbert's geometries. A good start is the following book:

Metric Spaces, Convexity and Nonpositive Curvature, IRMA Lectures in Mathematics & Theoretical Physics, by Athanase Papadopoulos, 2005.

3. Perron-Frobenius theory. The classical Perron-Frobenius theorem concerns the eigenvalues and eigenvectors of matrices with non-negative entries. It has numerous applications; for instance, in the analysis of Markov chains. The Perron-Frobenius theorem can be generalised to linear operators that leave a cone in a vector space invariant. In this project we will study this generalisation.

Nonnegative Matrices in the Mathematical Sciences, Classics in Applied Mathematics, by Abraham Berman and Robert J. Plemmons, (1987)

PROFESSOR EL MANSFIELD

1. **Actions of Lie groups**. These are groups which are parametrized by real or complex numbers. The best known examples are the rotation groups but there are lots more. The project will include an in depth look at some particular Lie groups and their actions, the invariants of the actions, and applications.
Literature:
"Matrix groups" (different books by various authors)
"Group theoretical methods and applications", Fässler and Stiefel.

2. **Maths and Music.** There are a couple of topics looking at the mathematics of sound waves such as those generated by drums; "can you hear the shape of a drum" is a famous question. Also the mathematics of music technology, which involves approximating sound waves for digital compression and storage purposes, has many interesting aspects.
Prerequisite: MA588 Mathematical Techniques &Differential Equations.
Literature:
http://www.maths.abdn.ac.uk/~bensondj/html/maths-music.html
"Music and Mathematics, From Pythagoras to Fractals" edited by Fauvel et al.
Musimathics, 2 volumes, Gareth Loy, MIT Press, 2006

DR JR MERRIMAN

1. Number Theory.
Various specific topics are available under this general heading. Most involve algebraic techniques with scope for computing numerical examples, for example,

1. Factorisation techniques for (large) integers;
2. Diophantine equations (e.g. solving $3x^3 + 4y^3 + 5z^3 = 0$ for integer x, y and z) and related number theory;
3. Elliptic curves and their applications (e.g. to factorisation or cryptography);
4. Reciprocity Laws (the simplest is Gauss's Law of Quadratic Reciprocity which appears in almost all books on elementary number theory);
5. Binary Forms (the quadratic case is important for arithmetic in quadratic numberfields) .

Most topics have a historical aspect which could be pursued.

2. **Algebraic geometry.**
One or two topics relating mainly to the problem of plotting a “good picture” of an implicitly defined algebraic curve with singularities; where good means better than MAPLE!

DR RJ SHANK

1. Non-Euclidean Geometry. An investigation of hyperbolic and/or projective geometry.
Preliminary reading:
D.A. Brannan, M.F. Esplen, J.J. Gray, "Geometry", Cambridge UP (1999).

2. Symmetries and Invariants of Polyhedra.
Preliminary reading: Chapter 8 of P.R. Cromwell, "Polyhedra" (Cambridge UP. 1997) and Chapter 7 of Cox, Little & O'Shea, "Ideals, Varieties, and Algorithms" (Springer-Verlag, 1993).

3. Topology. Possible projects include the classification of surfaces, an introduction to manifolds, or an introduction to the fundamental group.
Preliminary reading:
J. Weeks, "The Shape of Space", Marcel Dekker (1985)
M.A. Armstrong, "Basic Topology", Springer-Verlag (1983).

4. Galois Theory. Possible topics include field extensions, the insolvability of the quintic, and ruler-compass constructions.
Preliminary reading:
Ian Stewart, "Galois Theory", Chapman and Hall, (1973) (3rd edition 2003);
D.J.H. Garling, "A Course in Galois Theory", Cambridge UP (1987).

DR IAN WOOD

1. Introduction to Hilbert Spaces Many familiar methods of vector algebra and calculus from the two-dimensional Euclidean plane and three-dimensional space can be extended to spaces with any finite or infinite number of dimensions. This gives rise to the mathematical concept of a Hilbert space.

Hilbert spaces appear naturally and frequently in mathematics, physics, and engineering, typically as infinite-dimensional function spaces. They are indispensable tools in the theories of partial differential equations, quantum mechanics and Fourier analysis.

The project will look at basic properties of these spaces and some of the main examples that arise.
Literature:
J.Weidmann: Linear Operators in Hilbert Spaces, Springer, 1980.
N.Young: An Introduction to Hilbert Space, Cambridge University Press, 1988.

2. Sturm-Liouville Problems Sturm–Liouville equations are second-order linear differential equations. They can be used to descibe the vibration of strings, the motion of springs, electrical circuits and many other physical systems. The project will look at solutions to these equations and their properties, as well as some applications.

Literature:
M.Braun: Differential Equations and Their Applications, Springer, 1975.
N.Young: An Introduction to Hilbert Space, Cambridge University Press, 1988.

DR CF WOODCOCK

Various topics in Algebra and Geometry. For example:

1. **The Group Theory of Rubik's Cube.**
   The Rubik cube provides good illustrations of many of the basic concepts of group theory which in turn can be used to determine the possible configurations of the cube.

2. **Euler's Formula.**
   Euler's Formula and its generalisations have applications in many areas of Mathematics. In the simplest form it states that the number of vertices, edges and faces of a convex polyhedron are related by the formula $v - e + f = 2$.

Previous dissertation subjects include:
Galois theory and the solution of polynomial equations. Finite fields and coding theory. Continued fractions and Diophantine approximation. Cryptography.

STATISTICS TOPICS

DR L BREUER

Interested students should make an appointment in order to fix a suitable topic. The general area would be probability theory and stochastic processes, with applications in queueing, insurance risk and finance. Special topics include:

1. Simulation of stochastic processes
This helps students understand the construction and dynamic of processes. But there is also an interest from the research side. For special processes, e.g. inhomogeneous in time or space, transition matrices or first passage times have no closed form solution. Thus simulation is sometimes unavoidable.

2. Applications of stochastic processes
These would belong mainly to the fields of queueing theory and insurance mathematics. Required would be further reading based upon the course MA636/836.

DR DJ COLE

1. Parameter Redundancy in Ecological Models
Some models in ecological statistics have more parameters than it is possible to estimate. This parameter redundancy is not always obvious and can be detected using symbolic algebra. This project will involve programming the symbolic algebra in Maple and testing various models for parameter redundancy.
Reference: Morgan (2000) Applied Stochastic Modelling (section 5.3)

2. Prion Number Determination in Yeast Cells
Prions are infectious particles responsible for BSE and CJD in mammals, but are also found in yeast cells. Prion number determination is a method of determining how many prions there are in a yeast cell. This project involves investigating whether the data are well fitted by a Poisson distribution or if the data are more variable than the Poisson distribution. Estimates can then be found of how many prions there are in yeast cells.

3. Analysis of Teal Data
Teal are small dabbling ducks. This project would involve analysing data on Teal, which are marked and then recovered dead in subsequent years. Such data can be used to estimate annual survival rates of birds. The data also depend on the death of the bird being reported. Programs to estimate these different parameters could be written in Matlab to estimate such parameters or the computer package MARK could be used, see:
http://welcome.warnercnr.colostate.edu/~gwhite/mark/mark.htm
Reference: Morgan (2000) Applied Stochastic Modelling (see page 5 for similar data on herons)

DR J GRIFFIN

1. Stochastic Frontier Analysis using WinBUGs
This project will look at the stochastic frontier analysis approach to measuring the efficiency of economic units (such as hospitals or banks). You will look at the ideas behind the approach and implement Bayesian inference using the WinBUGS program.

2. The Lasso and Beyond
The successful application of regression techniques often depends on a good choice of variable to include in the model. Traditional methods such as forward or backward selection can sometimes perform poorly. This project will look at alternative, recently developed methods such as the Lasso, apply them to some data sets and compare their performance. The model fitting will use the R statistical package.

DR EFANG KONG

1. Variable selection in linear regression
Cross-validation method is a popular approach to select among a group of candidate models in terms of best predictive ability. This project will focus on the comparison of leave-one-out cross-validation and leave-m-out cross-validation in variable selection for linear regression models. Programming skills in Matlab or R will be necessary.

Reference: Shao, J. (1993) Linear Model Selection by Cross-Validation. Journal of the American Statistical Association, Vol. 88. 486-494.

2. Smoothing splines and applications
We focus on estimation of the regression curve of the response variable Y given x, f(x) which is believed to be nonlinear, using smoothing spline method. Important issues include selection of

number of knots and the smoothing parameter. Sound knowledge of linear algebra and programming are prerequisite.

Reference: R. Eubank.(1999) Nonparametric regression and spline smoothing: second edition. Dekker. Chapter 5.

DR A KUME

1. Simulation study for exploring the consistency of certain mean shape estimators.
The Shape of an object is defined as the geometrical information left after information about translation, rotation and scaling is removed. Statistical shape analysis involves finding sample mean shapes and statistical inference based on the shape spaces.
A particular set of programs for Splus will be used.

2. Statistical inference based on simple shape models, which can be applied to a range of data sets available.
In particular, for a certain population of gorillas we have made some measurements of their skulls, which are of various sizes depending on age. One question to answer is whether the shape of skulls of males is different from that of females. Programming in Splus will be necessary here.
Main reference: I.L. Dryden and K. V. Mardia, ``Statistical shape analysis,'' Wiley, Chichester, 1998.

3. Hyperbolic geometry and shape analysis This project will be based on understanding the geometrical structure of the shapes of triangles and their representation in hyperbolic spaces. Some computing will be needed.
Reference:The statistical theory of shape Christopher G. Small, Springer, New York1996.

DR OD LYNE

1. The National Lottery - it probably won't be you? The National Lottery provides a rich source of data. Are the numbers drawn truly random and how do we tell? How do people choose their numbers and is there any scope for choosing numbers better? This topic will require some computing.

References:
Haigh J (1997) The statistics of the National Lottery
Journal of the Royal Statistical Society Series A - Statistics in Society
Volume 160, part 2, pages 187-206.

2. Mastering Monopoly with Markov Chains. The movement of pieces around a Monopoly board can be modelled using a Markov Chain. This modelling should yield information on how frequently certain properties are landed upon and hence may inform Monopoly playing strategy. This topic will require some knowledge of Markov Chains (such as provided by MA636) and will require computing.
Reference:
Stewart I (1996) How fair is monopoly?
Scientific American, Volume 274, Issue 4, April, pages 104-105.

3. Statistical Inference for Epidemic models. Infectious diseases can be studied using stochastic models. Data from outbreaks of disease can provide crucial information about the spread of disease through a population. This topic will require some knowledge of stochastic modelling (such as provided by MA636) and will require computing in Matlab.
Reference:
Becker N (1989) Analysis of infectious disease data. London : Chapman and Hall.

PROFESSOR BJT MORGAN

I list a few possible topics in general terms below. If you would like to discuss these with me, then please check out the appropriate reference first, and then email me to arrange a time to come and talk about the project in more detail. All of my projects would involve some use of the computer.

1. **A topic in statistical ecology.** There are many possible topics here. The interested student might like initially to consult the book:
Williams, B.K., J.D. Nichols, and M.J. Conroy. 2002. Analysis and management of animal populations. Academic Press, San Diego. 817pp.
There are 4 copies of this book in the Templeman library, at: qQL752.
There would be opportunites, for instance, to use the computer package MARK, see:
http://welcome.warnercnr.colostate.edu/~gwhite/mark/mark.htm

2. Practical Bayesian statistics. Bayesian inference is described in the book by P.M. Lee:
Bayesian statistics : an introduction**.** Two copies are located at QA 279.5

In practice Bayesian inference may be conducted using an approach called Markov chain Monte Carlo (MCMC), and a convenient computer package is called Open BUGS; see
http://mathstat.helsinki.fi/openbugs/

A student doing this project would find out about Bayesian inference, would become familiar with Open BUGS (a free download), and use the package to run a variety of analyses to illustrate the theory. This project would be suitable for a student with an interest in modern statistical inference and who would have some interest in the use of computer packages.

3. Applied Stochastic Modelling. The reference book here is to be found at QA274 (two copies are available), by B.J.T. Morgan. This is the course text for the lecture course MA771, of the same name, that runs in the spring term. A student on this project would gain experience in running a range of MATLAB programs, and, if appropriate, the project would dove-tail well with MA771.

PROFESSOR MS RIDOUT

These topics are largely data-based and you would need to develop statistical computing skills and data handling skills to be able to manipulate the data and fit interesting models. The best statistical package to use would depend partly on your background and existing experience.

1. Service times in banks In a recent paper, available at
http://www.bentley.edu/csbigs/documents/Cogdill.pdf
two researchers analyse a very large data set on service times at an American bank. A subset of the data, covering 5 branches of the bank is available at
http://www.bentley.edu/csbigs/documents/CogdillMonticino.xls
These data give service times classified by the cashier involved and by the type of transaction. Even this subset of the data is quite substantial, with over 24,000 individual times. This makes it possible to compare service times between branches, between cashiers and between types of transaction and to fit different types of statistical distribution to model the variability in service times. This project could examine the sample data, fit various simple models and look at the implications for queueing times. This project would be most suitable for someone who is studying MA636 (Stochastic Processes) and/or MA772 (Analysis of Variance).

2. Modelling football match statistics A great deal of football-related data is available nowadays on the web and this can make for a variety of interesting projects. A particularly useful source of (free) data is
http://www.football-data.co.uk/data.php

Projects could look, for example, at statistical relationships between total shots, shots on target and goals scored (for example, do the relationships differ between home and away teams, or between different leagues)? Or one could look at statistical models that try to predict the result of a game (home win, away win, draw). Or one could look at disciplinary data (numbers of yellow and red cards).
Some quite sophisticated statistical models have been proposed to describe, for example, the joint distribution of home and away goals. However, some easy to use software available in the (freely downloadable) statistical package R should make it feasible to fit some of these models to the data.

3. Randomized response surveys

Do you download music illegally? Drink and drive? Take illegal drugs? Plagiarise your coursework? If somebody asked you questions like this in a survey, you might well decline to answer.

Randomized response is a survey technique designed for studying sensitive issues. Suppose, for example, that you are presented with two statements:

* I download music illegally.
* I do not download music illegally.

You then select one of these statements by some random mechanism and state (truthfully) whether the selected statement is true or false. The fact that you answered true or false gives nothing away, as no-one apart from you knows which question you answered. But, subject to some restrictions on the randomization process, statistical techniques can be used to estimate the proportion of the population who download illegally from a large sample of answers.

This project will investigate some of the many interesting questions about randomized response. How does it work in detail? Does it give unbiased estimates? How well does it protect people's privacy? Can we tell if people have cheated?

A good starting point is the original 1965 paper by Stanley Warner, which is freely available at
http://ihome.cuhk.edu.hk/~s0802340/sta300308/ref4_1.pdf

PROF SG WALKER

1. **Introduction to Markov chain Monte Carlo methods.**

This project would involve simulating a Markov chain in order to sample a distribution function and estimate quantities such as means of the distribution. Applications would involve Bayesian analysis of ARCH(1) model. Some computing work will be necessary.

2. **Large sample properties of estimators.**

This project would see how estimators of parameters behave as the sample size grows. When do they converge to the correct values or when can they become more misleading as more data accumulates.

3. **Decision Theory.**

This project would use formal methods for making decisions. The key is the notion of a decision between choices

i) an income of certain amount
ii) an uncertain income with known probability distribution

What is the formal basis for making such decisions?

DR XUE WANG

1. Analysis of nuclear magnetic resonance (NMR) data

The NMR signals have several pronounced features, including a large spike about halfway through the series. However, the observed signals exhibit a fair amount of apparent background noise. The aim of this project is to remove the background noise from the NMR signal without blurring or removing the features of the signal by using some statistics techniques. Some computing work will be necessary.

Reference: Abramovich , F., Bailey, T.C. and Sapatinas, T. (2000). Wavelet analysis and its statistical applications. The Statistician, 49, 1—29.

2. Multi-scale modelling method and application for the remote sensing terrain data

Multi-scale stochastic model has been applied broadly in many practical issues, such as image fusion, image denoising, boundary detection, and so on. In this project, you are expected to apply the multi-scale stochastic modelling thought in the image fusion, establish the multi-scale space state model which is suitable for the different remote sensing terrain data.

Reference: Zhang, L. (2004). Multi-resolution modelling and estimation of multi-sensor data. IEEE Trans. Signal Processing, 52, 3170—3182.