

The projects described are suitable for students from all UL undergraduate mathematics programmes. It is an absolute prerequisite that a student wishing to complete any of these projects, formally **meet** with Kevin Hayes and declare her/his interest. Ultimately, not all of the project offered will “run”. FYP titles will be withdrawn once my supervision quota has been reached.

[KH01] Designing a Student Evaluation of Teaching questionnaire for undergraduate Mathematics programmes at the University of Limerick.

The Centre for Teaching and Learning at the University of Limerick conducts Student Evaluation of Teaching surveys on behalf of faculty, for the purpose of providing reflective feedback. The evaluation is available to faculty from all disciplines and takes the form of a generic online WEB-based questionnaire using Survey-Monkey! The questionnaire itself has not been revised in over a decade, and as far as can be determined, did not incorporate student inputs in its construction. In contrast to similar questionnaires used by other Irish universities, the CTL questionnaire appears to be highly personalised, lacks objectivity, and takes no consideration of specialised academic disciplines. The aim of this project to to develop a specialised Student Evaluation of Teaching questionnaire for undergraduate Mathematics programmes at the university of Limerick. It is intended that the views of students from all years of the current mathematics undergraduate population be incorporated in the construction of the questionnaire. Inputs from faculty in the Department of Mathematics and Statistics will also be sought. The proposed questionnaire will be piloted on an undergraduate class, and the concurrent validity of the proposed instrument established (confirmatory factor analysis) as well as the instrument test-retest reliability (using Cohen’s kappa). The proposed instrument will be applied via an online WEB-based survey as well as a supervised completion of same. Statistical analysis will be used to determine the existence/absence of systematic biases. Protocols for the future administration of the process will be drawn up. The final proposal will be put to the department and class representative for approval or dismissal!

[KH02] Evaluating a UL mid-semester assessment based on randomly allocating students to one of two exam papers intended to be of the same standard.

The cunning ability of UL students to swindle in large class mid-semester assessments is well recognised, and at various times in the past faculty have implemented counter measures to make this more difficult. A strategy adopted by one lecturer in recent years is to distribute two different exam papers making in class copying more difficult. Each exam paper has ten multiple choice questions. Each question has 5 (not necessarily equally likely) possible answers. Question i on paper 1 exams the same material/topic/problem as question i on paper 2, and was designed by the lecturer to be of the same standard. Three years of test data are available. The exam scores in a given year take the form of a generalized linear model with binomial response, and this can be used to test for the existence of systematic differences between the two papers. This approach will be used to obtain a preliminary analysis of the data. The second part of the project will compare question i on the two papers using item response theory. The difficulty of a given question can be determined by a plot of $\mathbb{P}(\text{correct answer})$ against θ , where θ is a latent variable representing student ability. Monotone smoothing will be used to obtain the response curves for each question.

1. Rossi, N., Wang, X. and Ramsay, J. O. (2002) Nonparametric item response function estimates with the EM algorithm. *Journal of the Behavioral and Educational Sciences*, 27, 291–317.
2. Ramsay, J.O., and Silverman, B. (2005) *Functional Data Analysis*. Springer.
3. Faraway, J. (2006) *Extending the linear model with R*. Chapman Hall.

[KH03] Quantile Regression: Reference range of thyroid function test in pregnancy

Thyroid disease is the commonest endocrine condition in women of child-bearing age and complicates approximately 1-2% pregnancies. The hyper-metabolic state of normal pregnancy makes clinical assessment of thyroid function more difficult and therefore thyroid function often needs to be checked biochemically. However physiological changes of pregnancy, including 50% plasma volume expansion, increased thyroid binding globulin production and a relative iodine deficiency, mean that thyroid hormone reference ranges for non-pregnant women may not be appropriate in pregnancy. One acceptable approach for establishing legitimate reference ranges requires that a Box-Cox transformation be applied to the data, and prediction ranges calculated using using classical polynomial regression. Alternatively, non-parametric smoothing such as quantile can be used to estimate the 2.5% and 97.5% percentiles. Although this approach provides an estimate of the reference range, it does not routinely quantify the precision of the end points of this reference range. This is the aim of the project.

1. Ramsay, J.O., and Silverman, B. (2005) Functional Data Analysis. Springer.

[KH04] Model based Clustering of Kinematic Curves: Functional Data Analysis of Subjects with Chronic Achilles tendon Injuries

Anterior cruciate ligament (ACL) injuries are recognised as one of the most common and serious sports injuries with upwards of 250,000 ACL injuries occurring in the United States each year. Reconstructive surgery is typically recommended after ACL injury, to restore the knee joint stability and function required for sports participation. Almost 80% of athletes undergoing surgery are unable to successfully return to preinjury-level sport participation and therefore quit their sports. Athletes who are successful in rehabilitating from surgery and returning to their sport (ACLr subjects) have

been shown to be at an increased risk of repeated ACL injury to the previously reconstructed knee and the contralateral knee. Additionally up to 50% of ACLr individuals will display signs of osteoarthritis (OA) 10 years post injury. Altered biomechanics and neuromuscular function as a result of the initial ACL injury, affecting both the injured and the contralateral leg, are likely to increase the risk of a repeated ACL injury and degenerative joint disease. This project will take a model based clustering approach to kinematic curves obtained from video capture of injured subjects performing jump-and-cut tasks.

1. Coffey, N., Donoghue, O.A., Harrison, A.J., and Hayes, K. (2011) Common functional principal components analysis: a new approach to analyzing human movement data. *Human Movement Science*, Vol. 30, No. 6, pp.1144–1166.
2. Ramsay, J.O., and Silverman, B. (2005) *Functional Data Analysis*. Springer.

Donoghue, O.A., Harrison A.J., Coffey N., and hayes, K. (2008) *Functional Data Analysis of Running Kinematics in Chronic Achilles Tendon Injury*. Medicine & Science in Sports & Exercise.
3. Raftery, A.E. and Dean, N. (2006). Variable Selection for Model-Based Clustering. *Journal of the American Statistical Association*, 101, 168-178.
4. Fraley, C. and Raftery, A.E. (2002). Model-Based Clustering, Discriminant Analysis, and Density Estimation. *Journal of the American Statistical Association*, 97, 611-631.
5. Fraley C. and Raftery A.E. (2007). Model-based methods of classification: Using the mclust software in chemometrics. *Journal of Statistical Software*, 18, i06.

[KH05] Statistical Evaluation of Estimates of the Particle Size Distribution in Process Crystallization

This project considers application of functional data analysis to the estimation of probability distribution functions. The particular application to be considered involves the estimation of Particle Size Distribution in Process Crystallization. This particle size distribution is fundamental to all modeling stages of crystal growth. Estimates are obtained by averaging numerous 3D scans in particles in solution. However the statistical merits the estimates have not been studied. An improved understanding of the measurement process and alternative non-parametric statistical estimation procedures are sought.