7 MSc Projects with John Allwright

Model predictive control (2 projects)
Project codes JCA1 & JCA2
Model predictive control is a kind of control scheme that is much used in industry since it is probably the only practicable way of dealing with constraints. There are now many algorithms available and the aim of this project is to study some of the algorithms for robust control and test them by applying them to nontrivial Matlab simulations.

Optimization theory and Lyapunov theory are involved. Typically, about 50% of the time would be devoted to understanding the theory and 50% to Matlab programming.

The following tutorial papers will give you some idea about model predictive control - they are available as pdfs from IEEEexplore.

Rawlings, J.B.;
Control Systems Magazine, IEEE , Volume: 20 , Issue: 3 , June 2000
Pages:38 - 52

Tutorial: model predictive control technology
Rawlings, J.B.;
American Control Conference, 1999. Proceedings of the 1999 , Volume: 1 , 2-4 June 1999
Pages:662 - 676 Vol. 1

Nonlinear on-line control using Matlab and Simulink
Project code: JCA3
This involves developing a nonlinear control version (using software relays, etc.) of the present DTS coursework, using the same motor and circuit boards. You would need to learn how to programme using LabView. This might be useful to you later because LabView is much used in the outside world. It is not like Matlab because its programs are defined in a graphical way and because it is event-driven, Anyone taking my course *Stability and control of nonlinear systems* would have a suitable theoretical background - however we might need to study some theories in greater detail than in the course. This is a project for someone who likes programming and making things work !

Control of linear time-varying systems
JCA4
Control of time-varying systems is fundamentally more difficult than the control of time-invariant systems because, for example, choosing the feedback matrix $F(t)$ at each t so all the eigenvalues of $A(t) + B(t)F(t)$ have negative real parts does not guarantee stability for time-varying continous-time systems.. Some algorithms exist for dealing with the continuous-time case but they appear to be very sensitive to numerical problems. The main aim of this project is to study those algorithms and the numerical problems. We might also study a new theory for a class of linear time-varying problems that appears to enable the difficulty mentioned in the first sentence to be avoided. Time varying linear systems is one of my research areas and the project might eventually involve some of my recent work.
Probably 60% of the time would be spent on theory and the rest on Matlab examples.

An interesting starting-point is:
Efficient pole placement technique for linear time-variant SISO systems
Valasek, M.; Olgac, N.; Control Theory and Applications, IEE Proceedings- , Volume: 142 , Issue: 5 , Sept. 1995.

Robust eigenvalue assignment
JCA5
The standard methods for eigenvalue assignment that are taught in lecture courses here are not necessarily very good when there is uncertainty in the model being used. It turns out that very small changes in the model can have a very large effect on the closed-loop eigenvalues achieved by any particular set of feedback gains. You might have noticed this when doing Part IV of the DTS coursework. IEEExplore and Google reveal that there is a signficant number of papers out there.

The aim of this project is to survey the literature and test methods that have been proposed using Matlab examples. Probably 70% of the time will be devoted to understanding new theory and the rest to computational testing using Matlab. This is a project for someone who likes theory.

Observers for nonlinear systems
JCA6
The aim is to carry out a literature review, with illustrative Matlab examples, of this important topic. Two initial papers, available form IEEExplore are:

Moving horizon observers and observer-based control
Michalska, H.; Mayne, D.Q.;
Automatic Control, IEEE Transactions on ,Volume: 40 , Issue: 6 , June 1995
Pages:995 - 1006

Constrained state estimation for nonlinear discrete-time systems: stability and moving horizon approximations
Rao, C.V.; Rawlings, J.B.; Mayne, D.Q.;
Automatic Control, IEEE Transactions on ,Volume: 48 , Issue: 2 , Feb. 2003
Pages:246 - 258

Discrete-time systems with generalized holds
JCA7
Most of you will know a lot about zero order holds by now. What is possible if, instead of using a hold generating a rather boring kind of input (piece-wise constant for ZOHs, piecewise linear for FOHs), we choose the shape of the output of the hold in a more general way, matched to the particular plant being controlled? This question is studied by the theory of generalized holds. The aim of this project is to survey the literature and do illustrative examples using Matlab. A good starting point seems to be the paper

Control of linear systems using generalized sampled-data hold functions
Kabamba, P.;
Automatic Control, IEEE Transactions on , Volume: 32 , Issue: 9 , Sep 1987
Pages:772 - 783.