2011/2012 EIE Summer Research Project Scholarships

Project 1
Title: Distributed control of distributed energy resources
Supervisors: Dr Gregor Verbic, Prof David Hill

Summary
This project investigates possible agent-based distributed control hierarchies to enable efficient control and aggregation of large numbers of distributed energy resources.

Synopsis
The operation of a traditional electric power systems is based on the production of electric energy in large centralized power plants, usually located away from load centres. As a result, the control algorithms are predominantly "central" so they need information on the operation of all the underlying devices. The increased penetration of distributed energy resources will render the conventional centralized control approach impossible to handle. The control will need to be distributed so as to reduce the amount of information exchange. The aim of the project is to use multi-agent systems to enable scalability of the control by distributing control actions.

The student will contribute to a wider research project dealing with demand management at the residential level. The aim of this project is to develop a simulation platform in Jade, a Java based language for modelling of multi agent systems. The problem will be simplified by assuming that the agents, representing electricity consumers, posses enough information of the underlying physical system, so the focus will be on the modelling of agents and their interaction with the environment.

Requirements
Good programming skills, preferably in Java are required. Knowledge in using Matlab would be highly desirable. Some literature review will be required to learn the basics of multi agent systems.

Project 2
Title: Use of thermal masses as virtual energy storage
Supervisors: Dr Gregor Verbic, Prof David Hill

Summary
This project exploits the possibility of using thermal masses of residential buildings as a virtual energy storage. By proper manipulation of heating, ventilation and air conditioning, the energy consumption can be shifted from periods of high demand to periods of low demand.

Synopsis
It is widely recognized that energy storage will play a vital role in the transition from the conventional electric power systems to a Smart Grid. The energy storage will be needed to serve as an energy buffer that will enable efficient integration of various inherently intermittent energy sources. All the competing storage technologies are still relatively expensive, which hinder a widespread deployment. The search for the alternatives is therefore obvious. One possible alternative is to use electric vehicles that, when parked, present a free-to-use storage option.
However, battery cycling is considered a serious issue, as it severely reduces the battery's life time, which, in turn, has severe economic implications for the car owners. As an alternative, this project proposes to use thermal masses of residential buildings as a means of energy storage. Such storage will have minimal running costs. If the comfort level of the occupants is kept at the desired level, exploiting this option will be hardly noticed by the occupants. Almost every household has some appliances that are physically connected to a thermal system. Examples include heating, ventilation and air conditioning, refrigerators, and heat pumps. Therefore, such units can be switched off for certain amount of time without significantly affecting the temperature of the underlying physical system, i.e. without affecting comfort levels of the occupants. The key to a successful realization of this idea is in predicting the behaviour of the underlying physical system.

The student will contribute to a wider research project dealing with demand management at the residential level by developing a thermal model of a residential house and analyse its behaviours when subjected to manipulation of the air conditioner. Potential benefit for the electric power system will be weighed against the aggravation of the comfort level.

**Requirements**

Good knowledge in using Matlab would is required. Some literature review will be required to learn the basics of demand response and thermal modelling of physical systems.

**Project 3**

**Title:** Distributed control of urban feeder voltage

**Supervisors:** Prof David Hill, Dr Gregor Verbic

**Summary**

This project investigates possible strategies for planning and control towards more closely regulated urban street voltages allowing for the influence of feed-in solar and smart grid technologies.

**Synopsis**

The regulation of feeder voltage is traditionally done conservatively by estimating worst case loading and setting transformer and capacitor settings so that all voltages are within an acceptable range. Consequently, voltages as measured are on average higher than needed. This leads to inefficiency and excess capital costs. Furthermore, with solar feed-in, the voltages can be even more variable according to how the points of feed-in are distributed. With smart grid technologies measurements all along the feeder at smart meters and other sensors give the opportunity to know much more about the voltage profile in near real-time. Further, feedback control in a much more refined way becomes possible.

The aim of the project is to simulate some basic control schemes for voltage control based on the new information. One key comparison that will be explored is between centralised control from one overall controller and decentralized or distributed control where a certain amount of control is done locally.

The student will contribute to a wider research project dealing with a range of control schemes for smart grids. There is the opportunity to try to test new ideas in practice via connections to Ausgrid.

**Requirements**

Basic power systems knowledge, mainly power flows, and control. Good programming skills. Knowledge in using Matlab would be highly desirable.
**Project 4:**

**Title:** Discovering DNA sequences based on error control codes

**Supervisors:** Dr. Raymond Louie, A/Prof. Yonghui Li, Prof. Branka Vucetic

**Synopsis**

Error control codes have been widely used in communication systems to reduce errors in transmission. The general idea is that redundant symbols are first added to the useful data symbols (encoding), to form a transmitted symbol sequence. This symbol sequence passes through a noisy channel, which induces errors. At the receiver, the redundant symbols are utilized to obtain an estimate of the original transmitted symbol sequence (decoding), in the presence of these errors.

Error control codes have recently been applied to understanding the structure and generation of DNA. Specifically, to construct DNA sequences, the DNA in a nucleus is first copied (transcribed) to an mRNA sequence, which is then used for protein construction (translation and folding). One problem is that errors may occur during this process, which may result in a protein not based on the original DNA design. However, remarkably, the resulting protein often closely matches with the original design. This suggests some sort of encoding/decoding process occurring during protein construction. Recent results already indicate that certain DNA sequences are generated by BCH codes. The task of the student is to discover which DNA sequence is generated by a particular error control code. Understanding the structure of DNA sequences is crucial in analysing genetic disorders, which can cause fatal diseases such as cancer.

**Project 5:**

**Title:** Simulation Game Design for Resource Allocation in Wireless Communication

**Supervisors:** Dr. Wibowo Hardjawana, Prof. Branka Vucetic

**Synopsis**

Recently, a simulation game concept that combines the features of a game (competition, cooperation, rules, participants, role playing) with those of a simulation (incorporation of critical features of reality) through interaction between participants has been successfully applied to solve a long standing problem in medical science. In this project, the student will design a simulation game for solving a problem of efficient allocation of radio resources (e.g., frequency subcarriers and power) in wireless 4G cellular networks. The objective is to maximize the overall throughput, defined as the sum of all user data rates within a cell, in the presence of interference coming from users in adjacent cells. An agent-based wireless communication access system will be developed. The players are assigned fixed roles as distributors of radio resources. Each player will select resources to be used to serve the user terminals in his/her cell area. A resource allocation visualization table displaying the radio resources available in the cell will be developed. Thus each player simply marks the corresponding entry in this table when allocating resources to its user terminals. To aid each player in making decisions during the simulation games, interference information that indicates the interference seen by any of terminals in a cell is provided to each respective player.

The game can be used in education for teaching wireless engineering. Its learning outcome is to optimise the allocation of radio resources in a cellular network.
Project 6:

Title: Stimulus reconstruction using Electroencephalogram (EEG)
Supervisors: Dr. Alistair McEwan, Dr. Craig Jin

Synopsis

This project investigates new EEG signal processing techniques for stimulus reconstruction. We will use a 32 channel EEG system and auditory stimuli and investigate whether surface EEG has sufficient resolution for stimulus reconstruction.

Project 7:

Title: Next generation audio coding
Supervisors: Dr. Alistair McEwan, Dr. Craig Jin

Synopsis

Next generation audio coding involves the coding and compression of spatial audio so that higher spatial resolution is achieved. For example, we would like to be able to extract second-order signals from first-order encoded audio signals. This project explores spatial audio coding and its perceptual validity.