NICTA Canberra Node Advanced Course: *Continuous Wireless Communications*

Title of the course: Continuous Wireless Communications

Course director: Dr. Leif Hanlen (ANU adjunct)

Formal Description of course: This course exposes students to the application of operators and Hilbert Space techniques to communication systems. The abstract operator viewpoint is used to address fundamental questions such as dimensionality, and optimal multiple-input multiple-output wireless channel configurations. The course covers numerical modelling of communication channels, and concludes with an introduction to information theory from the viewpoint of operator channels.

Informal Description of course: Multiple-input multiple-output (MIMO) wireless systems are an active research topic around the world. Yet MIMO wireless systems may be considered as a specific example of a much broader class of communication systems. Famous results for MIMO wireless systems are presented and used to motivate an abstract view of communication systems. This broader class allows us to address *fundamental limits* for communication between locations. This course will expose students to a new and exciting research area developing here in RSISE. For exceptional students there are possibilities of publications arising as a result of their course-work.

Curriculum: Proposed course outline is as follows:

0. Functional analysis as applied to Communication Theory – *preliminary mathematics*

    - Separability, operators, compact operators, operator equations. Formalism taken from various sources, particularly **E. Kreysig** *Introductory Functional Analysis with Applications* and **R. A.**

Kennedy *Hilbert Spaces with Applications* RSISE graduate course notes.

1. **Point-wise MIMO** Modelling approaches
   - Discrete points – the standard "multi-antenna" approach, as given in **I.E. Telatar,** *Capacity of Multi-antenna Gaussian Channels*, **European Transactions on Telecommunications, 1995, volume 10, number 6, pp 585–595.**
   - Beamforming, simple channel models, problems associated with this approach.
2. **Concept:** Communication systems are a continuous parameter system, standard discrete channel models form a sub-class of communication problems.
   - Communication between domains as an operator
   - basis expansions, matrix form for communication operator, pointwise MIMO as a particular basis choice
3. Modelling techniques
   - Dimensionality of channels, communication channel decomposition, numerical estimation channel coefficients
4. Information theory for communication operators
   - Models for noise, capacity of operator channels, relating this back to the discrete point model. Material drawn freely from R. Gallager, *Information Theory and Reliable Communication*, particularly chap. 8

Presenter: Dr. Leif Hanlen (NICTA, ANU Adjunct)

Dates and Locations: Nominally, `start date`, daily, 10am-12pm in lecture room RSISE building, for two weeks.

Completion date of course: `start date`+3weeks

Notification date of course: `start date`+8weeks

Workload: 20 hours of lectures, 40 hours of assignments reading and preparation for lectures. No formal examination.

Assumed knowledge of course: Basic information theory, undergraduate linear algebra (bases, matrix theory, singular value decomposition) – eg. chapter 0 of Horn and Johnson *Matrix Analysis*, some introductory functional analysis will be helpful although not required

Prerequisites, entry requirements: Undergraduate engineering degree, undergraduate communications theory (particularly Fourier Series)

Assessment procedures: 4 assignments – one per module.

Assignment options for the course: Four assignments will be handed out during the course, a pass will be dependent upon satisfactory completion of the assignments.

Examiners: Prof. Rodney Kennedy (RSISE, ANU) and Dr. Leif Hanlen (NICTA, ANU Adjunct)

Fees: Nil