Professor William Holderbaum--deleted

Subjects: Automation & Control Systems

Contributor: William Holderbaum

I have been working at the University of Glasgow, the University of Reading, Manchester Metropolitan University and Aston University in the UK. i have played major leadership roles in research, whilst maintaining a very strong international reputation and an extensive list of industrial collaborations. i have over 120 publications and supervised 22 PhDs students and 9 Post-docs. Over the past twenty years, i have applied my control expertise to several applications and in particular rehabilitation engineering and energy transmission, storage for electrical systems, and power systems.

Keywords: control theory ; Energy ; Healthcare ; Robotics

My research concerns the theory of control systems and modelling with applications mainly focused on the following topics: Boolean input systems (i.e. power converter), Geometric Control (nonholonomic control systems), Rehabilitation Engineering (Robust Control Design for unsupported Paraplegic Standing), Energy reduction (Smart Grid, Multiple Agent Systems, Fuel Cells, Power Generation and Wireless Power Transfer), Autonomous Vehicle (Motion planning, visualisation control):

• Boolean input systems are sub-class of hybrid systems (Boolean + continuous) of a single model obtain from the Bond Graph modelling technique. I have developed theoretical control laws and studied the Lyapunov stability of systems with application to electrical motors in simulation. I have also extended hybrid control laws using a neural network approach. At the present time, I am studying a new approach from the stability point of view.

• The goal of rehabilitation engineering allows people to restore movement with Functional Electrical Stimulation. The human body is a complex system that is very difficult to control; I developed new strategies to integrate and/or to take into account those particular complexities. The direction of research involves patients with severe Spinal Cord Injury who have difficulties in transferring between poses (e.g. moving from a bed to a chair), and likewise for carers of patients with Spinal Cord Injuries who must avoid possible back pain due to incorrect lifting. This work investigates the dynamics involved in transferring, along with with Functional Electrical Stimulation (FES) methods to activate muscle groups at the appropriate phase of a sit-to-stand transfer. The overall control of the transfer would be shared between the carer and the individual with the Spinal Cord Injury.

• This research involves studying nonholonomic control systems whose configuration space can be described by a matrix Lie group. This framework provides a natural and mathematically rich setting for studying nonholonomic systems. In particular analysis tools from a diverse range of mathematical subjects such as group theory and differential geometry are used extensively. A transformation has been considered in the Hamiltonian setting which is the natural setting for conserved systems (systems with symmetry). The Hamiltonian equations can then be solved explicitly in many cases and as such global solutions of high dimensional systems can be obtained. In addition, the research extends much of the current theory to consider non-Euclidean spaces. This current work has been applied in the control of autonomous vehicles

• Energy is an important research topic and even more so today in order to reduce the overall CO2 emission. In this research, I use mathematical engineering skills in order to minimise the energy consumption in the home by adding storage combining with multiple agent systems. Another topic relates to the use of PhotoVoltaic (PV) cells and ThermoElectric (TE) to scavenge energy freely available around us. Control engineering renders this possible by managing the power betweens loads (demand) and generator (PV-TE). Other areas of energy-related research are wireless power transfer (which consists of modeling the efficiency of power transfer from Maxwell’s Equations) and fuels cells technology (estimation of the magnetic fields from the cells using classification algorithms). Further is to develop control methodology for energy storage (batteries, flywheel) using multiple agent systems to reduce peak demand in a distribution network based on day-ahead demand forecasts on a Low voltage Network.

• The research work on Unmanned Air Vehicle(UAV) focuses on the review and comparison of different existing algorithms from the literature for path planning. To perform such a comparison a benchmark environment is designed associated with performance metrics. Furthermore different control methods are being researched focusing on navigation and guidance using camera and sensors. Lastly, interesting research is emerging of UAV control. Indeed the development of computational methods for the design of optimal low thrust spacecraft trajectories subject to uncertainties (dynamics of the system, lack of accurate knowledge on the terminal constraints associated with a mission). Two alternative approaches based on stochastic sampling are being explored: The first approach will employ the unscented transformation to approximate the distribution of the control and state trajectories. The second approach is a modified particle control approach, whereby the probability distributions of the states and controls are iteratively approximated using sampling

The skills needed for the above fall into the broader category of mathematical science for engineering. I am a theoretical engineer who can combine a deeper understanding of theories as well as to apply these abstract notions to real engineering systems.
