Life Science Initiative Proposal 2015 Entry

**Proposed Project Title:** Detecting signatures in transient time series of physiological movement data

**Primary School:** School of Mathematical Sciences

**Proposed Primary Supervisor:** Wolfram Just

**Secondary School:** WHRI, School of Medicine and Dentistry

**Proposed Secondary Supervisor:** Dylan Morrissey

**Details of any additional members of the supervision team:** Raul Mondragon, Electronic Engineering and Computer Science

**Endorsement from Primary and Secondary Heads of School/Institute:** Both heads, Boris Khoruzhenko (SMS) and Tim Warner (SMD), are supporting the proposal. The primary school (SMS) will take care of the financial issues (central charges, consumables, etc.).

**Project Description:**

**The Research Area:** To combine knowledge of contemporary Mathematics, in particular topics in data analysis and dynamical systems theory, with some of the most challenging problems in life sciences, i.e., how to judge the health of a living organism from macroscopic observations, for the benefit of progress in both disciplines.

**Project Proposal:**

**Background:** Medical and biological time dependent data are usually affected by changes in the external and internal conditions, for instance by ageing and fatigue. These so called non stationary features limit the applicability of conventional statistical data analysis tools like correlation analysis or power spectra. Within SMD a large amount of human movement data are available with the goal to detect hidden injuries from complex observations of human movement and muscle activation. We intend to apply modern concepts developed in the context of dynamical systems theory to uncover signatures in non stationary or transient time series which can solve such issues.

The analytical starting point will concern the synchronisation of body parts using recently developed concepts like generalised-, lag-, or phase synchronisation following ideas which have been successfully applied to study the cardio-respiratory system. From the mathematical perspective we will apply and generalise concepts of analytic signal processing, phase detection, wavelets, and related tools to isolate characteristic signatures in transient time series, which are otherwise hidden when a conventional correlation analysis is applied. An important part of the project will be the adjustment of the data analysis concepts to the particular setting of movement data. In addition, the analysis is supposed to provide input to refine experimental setups and protocols, to detect injuries from transient time series data sets. From an applications perspective, Dr Morrissey is ideally placed to guide the analysis in terms of relevance to a range of clinical questions arising from the data sets.

**Aim:** Apply and develop new tools to analyse transient time series in medicine, biology, and beyond. To uncover signatures in actual movement data to contribute to the diagnostics of living organisms. As a specific aim we intend to determine signatures of movement data for diagnostics, and finally, to link such signatures to actual medical conditions of the individual. In this sense the aim is along the lines of the well established practise in medicine to use ECG data for cardiac health.

**Methods and Training:** Key to the project is a strong collaboration between mathematics, medicine, and engineering, to apply mathematical concepts in real life science experiments. The required expertise in dynamical systems theory, data analysis, and signal processing is provided by embedding the student in the mathematics research group structure, seminar series in mathematics and engineering on relevant subjects, and appropriate LTCC training. Expertise and understanding relevant experimental issues is vital for the success and will be enforced by regular lab visits and discussions. Further, the student will be fully involved in the process of capturing the type of data they will handle - yielding particular insight.

**Supervision and Management:** Regular exchange between the involved schools is paramount, being organised by interdisciplinary group meetings and seminars, to ensure strong coordination between ex-
periments and data analysis. Following good practises in SMS and SMD the PhD student will have a comprehensive supervision package. There will be minuted group meeting every week, followed by a full morning of bookable time to work with the supervisors and relevant practitioners to monitor the progress of the project and to trigger adjustment of the research direction if indicated. This is supplemented by an open door policy, ad hoc meetings and shared tasks. The group of the second supervisor (Dylan Morrissey) has been chosen to pilot the RDF for QMUL, an online application for researcher development via personal development planning from Vitae.ac.uk, and we use this tool to inform supervision meetings.

Both supervisors have a strong supervision record, innovate continually to improve doctoral teaching methods and are on an upward research career track while in addition, the second supervisor maintains clinical consultancy. This application is for PhD students to work directly on the clinical trial at the heart of an NIHR SCL fellowship.