# COMPUTATIONAL TECHNICHES IN CORONARY HEART DISEASE DETECTION

*C.A. Ledezma*, P.J. Tan, V. Díaz-Zuccarini

Mechanical Engineering, University College London, Torrington Place, London WC1E7JE

Cardiovascular diseases (CVDs) are the leading cause of death in Britain and in the world, they cause 26% of the deaths and account for £9 billion in healthcare expenditure in the UK. Of all CVDs, the coronary heart disease (CHD) afflicts the most people, it causes around 7.4 million deaths, per year, worldwide. CHD is an occlusion of the vessels that irrigate the heart, causing a lack of oxygen supply (ischaemia). Currently, there are little to no methods capable of accurately detecting CHD at its early stages, when treatment may be more effective. Consequently, early detection of CHD is one of the most pressing issues in modern biomedical engineering. In this scope, there are three main challenges that need addressing: first, CHD often presents itself as a 'silent' disease (there are no symptoms), a heart attack or a stroke come as its first warnings; second, data is only available for the severe stages of CHD (because the disease is silent), data for early stages is limited; finally, risk assessment strategies must deal with inter-subject variabilities, which means that two similar patients may have a different underlying physiology. This work tackles these challenges by combining state of the art methods in mathematical modelling, machine learning and big data analytics.

In this work, mathematical models for electrophysiology (i.e. equations that reproduce the electrical activity of the heart) were used to emulate the interaction of cardiac cells and to produce virtual electrocardiogram (ECG) signals. Then, the models were altered to reproduce ischaemia, and the effects that the different degrees of vessel occlusion had on the virtual ECG signals were analysed and quantified. Furthermore, these models were adapted to simulate different patients and investigate inter-subject variability in diagnosing CHD. This computational approach allowed to generate virtual ECG signals of populations of patients, representative of the different stages of CHD. Finally, these populations were used to train a Machine Learning (ML) model that could detect CHD in an early stage using ECG biomarkers.

The results of this work proved how mathematical models can be used to infer cellular level physiology, which would require invasive explorations, by using ECG acquisitions, which are non-invasive. This 'bridge' between organ and cellular behaviour was then used to identify the ECG biomarkers that underpin CHD and, in concert with Machine Learning, allowed the detection of CHD at an early stage. Using the most novel techniques in mathematical modelling, machine learning and big data science, this work presents innovative methods that can identify life-threatening diseases, at an early stage, using minimally invasive acquisitions. The future implementation of these techniques in routine cardiology visits could improve the quality of life of the 7 million people currently living with 'silent' CVDs in the United Kingdom.