euHeart

Personalised & Integrated Cardiac Care: Patient-specific Cardiovascular Modelling and Simulation for In Silico Disease Understanding & Management and for Medical Device Evaluation & Optimization

The euHeart project aims to use patient-specific cardiovascular modelling as biophysically-based integration framework to improve the diagnosis, planning, and treatment of cardiovascular disease and to reduce the allied healthcare costs.

Objectives of the Project

Cardiovascular disease (CVD) is a highly relevant and epidemiologically significant contributor to loss of quality and quantity of life within Europe with considerable impact on the European economy.

Numerous diagnostic techniques are available to assess the presence and severity of CVD, ranging from electrocardiography (ECG) through imaging techniques (e.g. magnetic resonance imaging) to invasive tests. These techniques have been continuously refined, and can now derive exact and quantitative data. However, in current clinical practice data from different modalities are not optimally combined. Results from different tests may even be contradictory, as they measure different aspects of disease, which vary considerable even in healthy people.

euHeart aims to improve diagnosis, planning and treatment of CVD by using new computing tools and modelling approaches to generate patient-specific models of the heart and the aorta in clinical environments.

euHeart develops and uses multi-scale models linking molecular, sub-cellular and cellular functions to whole organ performance, via physiological function. These models provide a consistent, biophysically-based framework for the integration of the fragmented and inhomogeneous data currently available, which can be efficiently used to improve the outcome of CVD treatments. In addition, these models help understand the complex and multi-factorial disease mechanisms which play a key role in the pathology of disease.

> **"euHeart will allow to select the best therapy and to optimize treatment outcome for individual patients affected by cardiovascular disease."**

Project Description

Clinical focus – euHeart will collect evidence of clinical benefit to quantify the potential impact of multi-scale modelling for a number of CVD and associated therapies which are significant in terms of both healthcare spent and quality of life in Europe:

- heart failure through cardiac resynchronization therapy (CRT)
- heart failure through congenital cardiac surgery and left ventricular assist devices
- cardiac rhythm disorder through radiofrequency ablation
- coronary artery disease through revascularization using coronary stents and pharmacologic therapies
- diagnosis and treatment of valvular and aortic diseases.

Each of the selected clinical applications provides a complementary focus for the resulting integrated models of cardiac fluid-electro-mechanical function.

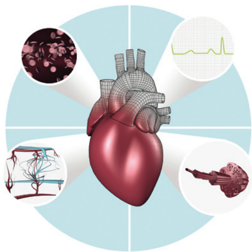
Validation – Model validation is carried out in clinical environments on cohorts of patients using dedicated prototypes. In addition, one multicenter pilot trial, including approximately 120 patients, will be performed to demonstrate the clinical benefit in determining the optimal lead placement and pacing sequence in CRT, a treatment that improves the coordination of the heart's contraction.

Multi-disciplinary project – The development of clinical prototypes requires the integration of numerous multi-disciplinary tools which are developed leveraging the complementary expertise available within the **euHeart** consortium. More specifically, the focus is on the following activities:

SCENARIO

Jim M., 60 years old, survived a severe heart attack which affected part of his heart muscle irrecoverably, leading to congestive heart failure. As the symptoms worsen despite optimal drug therapy, Jim's cardiologist thinks about implanting a pacemaker system (CRT) to optimize his heart function. The wide range of anatomical and functional data collected during the examinations is then provided to the euHeart system which personalises a virtual heart model to reflect Jim's conditions. This personalised computer model predicts, that Jim will respond well to the implantation. It also proposes an optimal treatment plan indicating where to position the pacemaker leads in the heart and how to operate them. This plan is finally combined with interventional data to guide the cardiologist during his manipulations.

- To develop, exchange and integrate multi-physics and multi-scale models of the heart and aorta in normal and pathological conditions using the international encoding standards CellML and FieldML. Recently, **euHeartDB, a web-enabled database for sharing and reusing anatomical models of the heart** has been released (https://euheartdb.physiomeproject.org/euHeartWebInt)
- To develop and apply strategies for model personalisation, i.e. to make computer models reflect the condition of a specific patient using anatomical and functional information. Effective personalisation is a crucial component to enable personalisation of care.
- To develop and validate automated methods for the consistent interpretation of multi-modal clinical images, a prerequisite to enable translation into clinical environments.
- To develop tools for the fusion and visualization of the clinical data and physiological information into the same spatial and temporal domains.
- To develop environments for the optimization of surgical interventions and tuning of devices for better treatment delivery and clinical outcome.



Expected Results & Impacts

The patients / society

- improvement of treatment through personalisation of care (vs. basic guidelines)
- increased safety of care through integration into image guided interventional systems
- reduction of medical costs and treatment duration

The clinicians

- higher confidence in decisions through better quantification of CVD
- improved therapy outcome through *in silico*-based optimised planning
- better understanding of the underlying pathology
- consistent biophysically-based platform for the integration of the fragmented and inhomogeneous data acquired throughout the cardiac care cycle

The industry

- improved analysis software moving from purely descriptive data interpretation towards biophysically-based disease quantification and prediction of disease progression
- personalisation of implantable devices through patient-specific simulations optimizing treatment outcome
- enhancement of interventional devices

KEYWORDS
Virtual physiological human, Clinical applications, Modelling of physiolgical processes, In silico simulation, Medical image processing and analysis

euHeart

Personalised & Integrated Cardiac Care: Patient-specific Cardiovascular Modelling and Simulation for In Silico Disease Understanding & Management and for Medical Device Evaluation & Optimization

Project co-ordinator:
Olivier Ecabert – Philips Technologie GmbH

Scientific co-ordinator:
Nicolas Smith – The University of Oxford

Contact person:
Olivier Ecabert
Tel: +49 241 6003 377
Fax: +49 241 6003 442
Email: olivier.ecabert@philips.com
Website: www.euHeart.eu, www.vph-euheart.eu

Partners:

- Philips Technologie GmbH (Germany)
- The University of Oxford (United Kingdom)
- Universitat Pompeu Fabra (Spain)
- The University of Sheffield (United Kingdom)
- Institut National de Recherche en Informatique et Automatique, INRIA (France)
- King's College London (United Kingdom)
- Academisch Medisch Centrum bij de Universiteit van Amsterdam (The Netherlands)
- Universität Karlsruhe (TH) (Germany)
- Institut National de la Santé et de la Recherche Médicale, INSERM (France)
- Deutsches Krebsforschungszentrum Heidelberg (Germany)
- Hospital Clínico San Carlos de Madrid (Spain)
- Philips Medical Systems Nederland BV (The Netherlands)
- Berlin Heart GmbH (Germany)
- HemoLab BV (The Netherlands)
- Volcano Europe SA / NV (Belgium)
- PolyDimensions GmbH (Germany)
- Philips Ibérica S.A. (Spain)

Timetable: from June 2008 to May 2012
Total cost: € 19,053,465
EC funding: € 13,900,000
Instrument: IP
Project Identifier: FP7-2008-IST-224495