Preface

Recently, there has been considerable progress in cardiac image analysis techniques, cardiac atlases, and computational models, which can integrate data from large-scale databases of heart shape, function, and physiology. Integrative models of cardiac function are important for understanding disease, evaluating treatment, and planning intervention. However, significant clinical translation of these tools is constrained by the lack of complete and rigorous technical and clinical validation, as well as benchmarking of the developed tools. For doing so, common and available ground-truth data capturing generic knowledge on the healthy and pathological heart is required. This knowledge can be acquired through the building of statistical models of the heart. Several efforts are now established to provide web-accessible structural and functional atlases of the normal and pathological heart for clinical, research, and educational purposes. We believe all these approaches will only be effectively developed through collaboration across the full research scope of the imaging and modelling communities.

STACOM 2014 was held in conjunction with the MICCAI 2014 conference (Boston, USA), following the past four editions: STACOM 2013 (Nagoya, Japan), STACOM 2012 (Nice, France), STACOM 2011 (Toronto, Canada), and STACOM 2010 (2010, Beijing, China). STACOM 2014 provided a forum for discussion of the latest developments in the areas of statistical atlases and computational imaging and modelling of the heart. The topics of the workshop included: cardiac image processing, atlas construction, statistical modelling of cardiac function across different patient populations, cardiac mapping, cardiac computational physiology, model customization, atlas-based functional analysis, ontological schemata for data and results, integrated functional and structural analyses, as well as the pre-clinical and clinical applicability of these methods. STACOM 2014 drew submissions from around the World and 30 selected papers were invited to be published by Springer in this *Lecture Notes in Computer Science* volume. Besides regular contributions concerning the state-of-the-art cardiac image analysis techniques, computational models that integrate data from large-scale databases of heart shape, as well as function and physiology, additional efforts of this year's STACOM 2014 workshop were focused on two imaging and modelling challenges described below.

Motion Correction challenge. Dynamic contrast MR myocardial perfusion imaging has evolved into an accurate technique for diagnosis of coronary artery disease. To quantify the time-series data, motion-free data is desired. The problem is then to handle the inter-frame motion artifact caused by respiration, which makes quantitative analyses difficult. Several methods have been proposed in the last decade, which can be categorized into two groups: rigid and non-rigid registration techniques. Rigid registration is computationally more efficient, robust to noise, and provides better consistency. Non-rigid registration however provides better alignment if there is cardiac motion due to for example through-plane motion, but it is more susceptible to noise and requires more computation. It is also not clear if images with tissue from out of plane should be used, or if instead the time frame should be discarded. However, all of these methods are still limited in clinical acceptance, and this is due in part to the absence of unbiased algorithmic validation framework using a common multi-centre dataset. The STACOM 2014 *Motion Correction challenge* was designed to test the hypothesis that there is no significant differences in terms of perfusion values from MR images that have been corrected either by non-rigid or rigid methods. Data and results from this challenge have highlighted the range of methods available and objectively characterized them in terms of the resulting blood flow.

LV mechanics challenge. Understanding the mechanical behaviour of the heart is important in the evaluation of cardiac disease. In particular, patients with heart failure can present with a spectrum of symptoms from preserved to reduced ejection fraction. Currently it is difficult to determine the passive stiffness properties as well as the active tension development during systole. Recently, a number of methods were proposed for utilizing image information to reverse engineer the mechanical properties of the heart. These take the form of mathematical simulations of the cardiac cycle. However, there was no objective comparison of the characteristics of these approaches. The STACOM 2014 *LV mechanics challenge* was designed to compare the behaviour of different methods used to simulate the systolic and diastolic mechanics of the left ventricle. The data include mesh point clouds and binary masks defining the LV geometry, and muscle fibre orientations derived from ex-vivo diffusion tensor MRI. Geometries at three states in the cardiac cycle were given: unloaded (diastasis), end of inflation (end-diastole), and end of contraction (end-systole). In-vivo left ventricular pressures and volumes were also provided throughout the cardiac cycle. This challenge enables discussion of which boundary conditions and what assumptions should be made for clinical evaluation of heart stiffness and contractility.

We hope that the results obtained by these two challenges, along with all regular paper contributions, will act to accelerate progress in the important areas of heart function and structure analysis.

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