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Statistical Atlases and Computational Models of the Heart

ACDC and MMWHS Challenges

8th International Workshop, STACOM 2017
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Revised Selected Papers

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Preface

Integrative models of cardiac function are important for understanding disease, evaluating treatment, and planning intervention. In recent years, 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. 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. To this end, common and available ground-truth data capturing generic knowledge on the healthy and pathological heart are required. 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 that these approaches will only be effectively developed through collaboration across the full research scope of the cardiac imaging and modeling communities.

STACOM 2017 was held in conjunction with the MICCAI 2017 international conference (Quebec City, Canada), following the past seven editions: STACOM 2010 (2010, Beijing, China), STACOM 2011 (Toronto, Canada), STACOM 2012 (Nice, France), STACOM 2013 (Nagoya, Japan), STACOM 2014 (Boston, USA), STACOM 2015 (Munich, Germany), and STACOM 2016 (Athens, Greece). STACOM 2017 provided a forum in which to discuss the latest developments in various areas of computational imaging and modeling of the heart as well as statistical cardiac atlases. The topics of the workshop included: cardiac imaging and image processing, atlas construction, statistical modeling of cardiac function across different patient populations, 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. Besides regular contributing papers, additional efforts of this year's STACOM workshop were also focused on two challenges: ACDC and MM-WHS, described here. A total of 27 papers (regular papers and from the two challenges) were accepted to be presented at STACOM 2017, and are published in this LNCS proceedings volume.

ACDC Automatic Cardiac Diagnostic Challenge

The overarching objective of this challenge is two-fold:

(1) To compare the performance of automatic MRI segmentation methods on the left ventricular endocardium and epicardium as well as the right ventricular endocardium for both the end-diastolic and end-systolic phase instances

(2) To compare the performance of automatic methods for the classification of examinations in five classes (normal case, myocardial infarction with altered left ventricular ejection fraction, dilated cardiomyopathy, hypertrophic cardiomyopathy, abnormal right ventricle)

The overall AC-DC dataset contains real clinical examinations from 150 patients all acquired at the University Hospital of Dijon (France). Each patient dataset comes with two ground truth information: (1) the pathology the patient suffers from and (2) a pixel-accurate delineation of each cardiac region (the endocardial wall of the left ventricle and of the right ventricles, and the epicardial wall of the left ventricle). The segmentation ground truths were manually drawn by two experts (a cardiologist and a nuclear medicine physician with experience in cardiology and MRI). The delineation was done for the most important phases of the cardiac cycle, i.e., diastole and systole. The diastolic phase is the first image acquired after the R-wave of the ECG while the systolic phase is the moment when the mitral valve reaches its maximum excursion and the myocardium reaches its maximum contraction. The dataset as well as the results obtained by the challengers can be found here: http://acdc.creatis.insa-lyon.fr/.

MM-WHS — Multi-Modal Whole-Heart Segmentation Challenge

Accurate computing, modeling, and analysis of the whole-heart substructures from 3D medical image scans is important in the development of clinical applications. Segmentation and registration of whole-heart images is, however, still challenging. The extraction and modeling of whole-heart substructures currently relies heavily on manual delineation, which is a time-consuming task and is also prone to errors and dependent on the expertise of the observer; therefore, fully automated methods are highly desirable. Over the past decade, many techniques have been proposed to solve this ill-posed problem, particularly for whole-heart segmentation, such as atlas-based methods, statistical shape model-based methods, and recently emerged deep-learning-based methods. The organized MM-WHS Challenge provided an open and fair competition for various research groups to test and validate their methods, particularly whole-heart segmentation, on datasets that were acquired in real clinical environments. The aim of the MM-WHS Challenge was not only to benchmark various whole-heart segmentation algorithms, but also to cover the topic of general cardiac image segmentation, registration, and modeling, and to raise discussions for further technical development and clinical deployment.

The organizers provided more than 120 datasets from multiple sites, including 60 cardiac CT/CTA and 60 cardiac MRI volumes in 3D that cover whole-heart substructures for multi-modality whole-heart segmentation. All these clinical data received institutional ethic approval and were anonymized. Both cardiac CT and cardiac MRI data were acquired in real clinical environment for patients that cover a wide range of cardiac diseases as well as normal controls. We received great interest from participants all over the world and the proposed methods have achieved substantial methodological innovations and significant performance improvement. We aim at keeping the MM-WHS Challenge as a long-term event for participants who may not be able to enter the competition, but are interested in further developments. All the relevant information and challenge results can be found at: http://www.sdspeople.fudan.edu.cn/zhuangxiahai/0/mmwhs/.

We would like to thank all organizers, reviewers, authors, and sponsors for their time, efforts, contributions, and financial support in making STACOM 2017 a successful event. We hope that the results obtained by these two challenges, along with the regular paper contributions, will act to accelerate progress in the important areas of cardiac image analysis, heart function, and structure analysis.

September 2017

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Contents