

Contraction Sequence of the Left cardiac Ventricle: A Case for High Frame Rate Ultrasound

by
Martin Sieminski Andersen

This dissertation sought to find a methodology for visualization and quantification of the propagation of mechanical waves through the left ventricle (LV). It used the T5 system for image acquisition. The T5 is an experimental phased array ultrasound system capable of up to 2500 fps for some application or 1000 fps for adult cardiac imaging using full field of view while simultaneously showing a live display of the images. Validation image sequences were generated using a high precision translation stage capable of horizontal and vertical motion at 10 μm increments and a tissue mimicking phantom. The second type of images were high frame rate (HFR) in vivo cardiac images with frame rates between 300 fps and 1000 fps. Study A and B presented the Continuous Feature-Tracking (CFT) algorithm, which was capable of accurately describing kinematics. The CFT algorithm was not limited to motion along the axial direction, by analyzing length of line strain in the parasternal short-axis view. Study C was the first study to show a statistically significant mechanical propagation origin for patients with echocardiographic normal LV function: The mid septal wall segment. These identified waves were consistently moving faster than the electrical excitation velocity through the electrical pathways of the Left Bundle Branch (LBB) and Purkinje network. A new visualization method using strain rate called a Strain Rate Image was developed. The strain rate emphasized changes in the myocardial deformation while presenting them as an image, which made visual interpretation of contraction propagation possible. Study D found statistical significant differences in the duration of the transient wave associated with tissue shortening between patients with echocardiographic normal LV function, LBB block (LBBB), and non-LBBB conduction disorders. Furthermore, a new method using a modified correlation coefficient was developed, which in turn illustrated significantly different measurements when comparing the patient groups. This thesis showed that it was possible to extract propagating mechanical waves from HFR B-mode echocardiographic images. Differences of transient mechanical events between different patient groups were identified. Finally, a proof-of-concept showed how strain should be used in conjunction with HFR echocardiographic images when identifying myocardial deformation.

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PhD lecture

By

Martin Sieminski Andersen

Thursday 3 October 2019



DEPARTMENT OF HEALTH SCIENCE AND TECHNOLOGY
AALBORG UNIVERSITY

This thesis is based on
Martin Sieminski Andersen's research work at:

Department of Health Science and Technology
Aalborg University, Denmark

To fulfill the requirements for the PhD degree, Martin Sieminski Andersen has submitted the thesis: Contraction Sequence of the Left cardiac Ventricle: A Case for High Frame Rate Ultrasound, to the Faculty Council of Medicine at Aalborg University.

The Faculty Council has appointed the following adjudication committee to evaluate the thesis and the associated lecture:

Professor Jan D'hooge
Katholieke Universiteit Leuven
Belgium

Professor Asbjørn Støylen
Norwegian University of Science and Technology
Norway

Chairman:
Associate Professor Dan S. Karbing
Aalborg University
Denmark

Moderator:
Associate Professor Claus Graff
Aalborg University
Denmark

The PhD lecture is public and will take place on:

Thursday 3 October 2019 at 13:00
Aalborg University – Room D2-106
Fredrik Bajers Vej 7 D2
9220 Aalborg East

Program for PhD lecture on

Thursday 3 October 2019

by

Martin Sieminski Andersen

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Moderator: Associate Professor Claus Graff

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| 13.00 | Opening by the Moderator |
| 13.05 | PhD lecture by Martin Sieminski Andersen |
| 13.50 | Break |
| 14.00 | Questions and comments from the Committee
Questions and comments from the audience at the
Moderator's discretion |
| 16.00 | Conclusion of the session by the Moderator |

After the session a reception will be arranged