Real-time estimation and characterization of physiological organ deformations for MR-guided interventional therapies

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REAL-TIME ESTIMATION AND CHARACTERIZATION OF PHYSIOLOGICAL ORGAN DEFORMATIONS FOR MR-GUIDED INTERVENTIONAL THERAPIES

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ABSTRACT

Recent developments in rapid Magnetic Resonance Imaging (MRI), associated with fast image processing techniques allow acquiring functional and positional information in real-time, which can be conveniently used on-line to control a cancer therapy, using High Intensity Focused Ultrasound or Radio Therapy. Real-time image-based strategies are currently under active developement for motion estimation of abdominal organs and for correcting motion related artifacts.

1. INTRODUCTION

Real-time processing of MR-images, combined with a High Intensity Focused Ultrasound system (MR-HIFU) with electronic displacement of the focal point, can be used to achieve a regional temperature control [1]. Similarly, the recent development of integrated MRI linear accelerators (MR-LinAc), designed for simultaneous irradiation and MR-imaging, shows great potential for on-line radiotherapy guidance.

Although these new techniques appear well suited for cancer therapy in vital organs such as kidney and liver, physiological displacements induced by breathing and/or cardiac activities require a precise real-time motion management to ensure: 1) A correction of motion-induced image artifacts (in particular, MR-susceptibility variations generate apparent temperature perturbations in the case of MR-HIFU, as well as geometric image distortions in the case of both MR-HIFU and MR-LinAc) ; 2) An accurate calculation of the accumulated dose (based on MR-thermometry for thermal dose assessment with MR-HIFU or dose simulations with MR-LinAc) ; 3) A reliable beam targeting of the pathological tissue.

Fast MR-acquisition protocols allow acquiring dynamically 2D images with a good contrast which can be conveniently used to estimate organ displacements during the therapy using image registration algorithms[1]. In addition, strategies are being developed to correct motion artifacts on-line, based on the quantitative and real-time characterization of individual physiological contributions such as breathing and cardiac activities [2].

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[1] http://bsenneville.free.fr/RealTITracker/

2. RESULTS

Fig. 1 reports a Principal Component Analysis (PCA) approach which detects, in a preparative learning step, spatio-temporal coherences in the targeted organ motion. During thermometry, incoherent motion patterns were discarded to improve the robustness of the motion estimation process and the compensation of motion related errors in thermal maps.

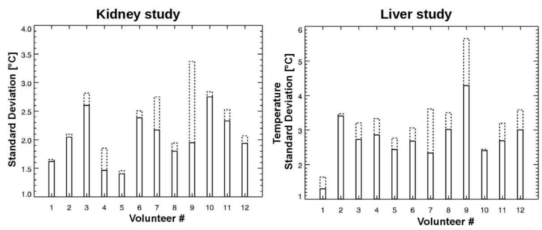

Fig. 1. Temperature precision obtained in the abdomen of twelve volunteers when the temperature maps were computed using an affine motion model (dash line) and the tested PCA-based description (solid line).

3. CONCLUSION

Recent developements open great perspective to address both target tracking and compensation of motion artifacts by applying high frame rate MRI coupled with a real-time motion characterization obtained from all incoming images.

4. REFERENCES

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