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Robust 3D tracking for robotic-assisted beating heart surgery

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I. INTRODUCTION

The past decades have witnessed the notable development of minimally invasive surgery (MIS). The benefits of this modality of surgery for patients are numerous, shortening convalescence, reducing trauma and surgery costs. In this context, robotic assistance aims to make the surgical act more intuitive and safer. In the domain of cardiac MIS, heartbeat and respiration represent two important sources of disturbances. Even though miniaturized versions of heart stabilizers have been conceived for the MIS scenario, residual motion is still considerable and has to be manually canceled by the surgeon. Our work focuses on computer vision techniques for estimating the 3D motion of the heart relying solely on natural structures on the heart surface for active compensation of physiological motions. We have developed in [2] a visual tracking method for estimating the 3D deformation of a region of interest on the heart surface based on the visual feedback of a stereo endoscope. The method is robust to illumination variations and large tissue deformations (Fig. 1).

For increasing tracking robustness [1] facing occlusions and tracking failures, motion prediction is integrated to the visual tracking task. In [3], a time-varying dual Fourier series for modeling the quasi-periodic beating heart motion is proposed. For estimating the parameters of the Fourier series, a probabilistic framework is based on the Extended Kalman filter (EKF) is used [4]. Finally, the heart motion prediction is integrated in the visual tracking framework, creating a unified method for estimating the temporal motion and spatial deformation of the heart surface. Experimental results have shown the effectiveness of the proposed methods.

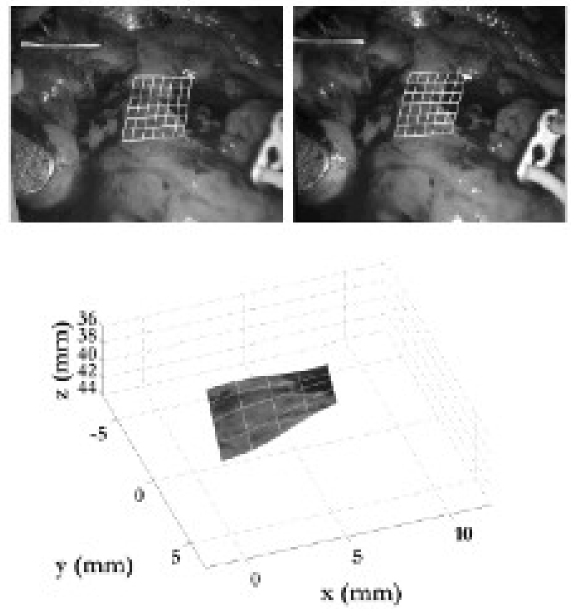

Fig. 1. A target region of interest on the heart tracked in 3D using the method based on the Thin-Plate Spline model proposed in [2]

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REFERENCES

[1] Richa R., Bo A.P.L., Poignet P., Toward Robust 3D Visual Tracking for Motion Compensation in Beating Heart Surgery, *Medical Image Analysis*, doi:10.1016/j.media.2010.12.002, available on-line, 2010.

[2] Richa R., Poignet P., Liu C., 3D Motion Tracking for Beating Heart Surgery Using a Thin-Plate Spline Deformable Model, *The International Journal of Robotics Research (IJRR)* - Special Issue on Robot Vision 29 (2-3) (2010) pp. 218-230.

[3] Richa R., Bo A. P. L., Poignet P., Beating Heart Motion Prediction for Robust Visual Tracking, *In Proceedings of IEEE Conference on Robotics and Automation* (ICRA '10), pages 4579–4584, Anchorage, USA, 2010.

[4] Richa R., Bo A. P. L., Poignet P., Motion Prediction for Tracking the Beating Heart, *In Proceedings of IEEE International Conference of the Engineering in Medicine and Biology Society* (EMBS '08), pp. 3261-3264, Vancouver, Canada, 2008.

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