Image guided therapy applications using Time-Of-Flight camera data

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LEHRSTUHL FÜR MUSTER-ERKENNUNG

Introduction

- Time-of-Flight cameras actively illuminate scenes with modulated light and delivers a real-time 3-D point cloud
- Example applications are: respiratory motion detection / gating, quantitative 3-D endoscopy and patient positioning

Patient positioning as an example application:

- Accurate patient positioning in radiotherapy and particle therapy is important for an accurate dose delivery [1]
- Alignment of treatment plan with patient coordinate system

Materials and Methods

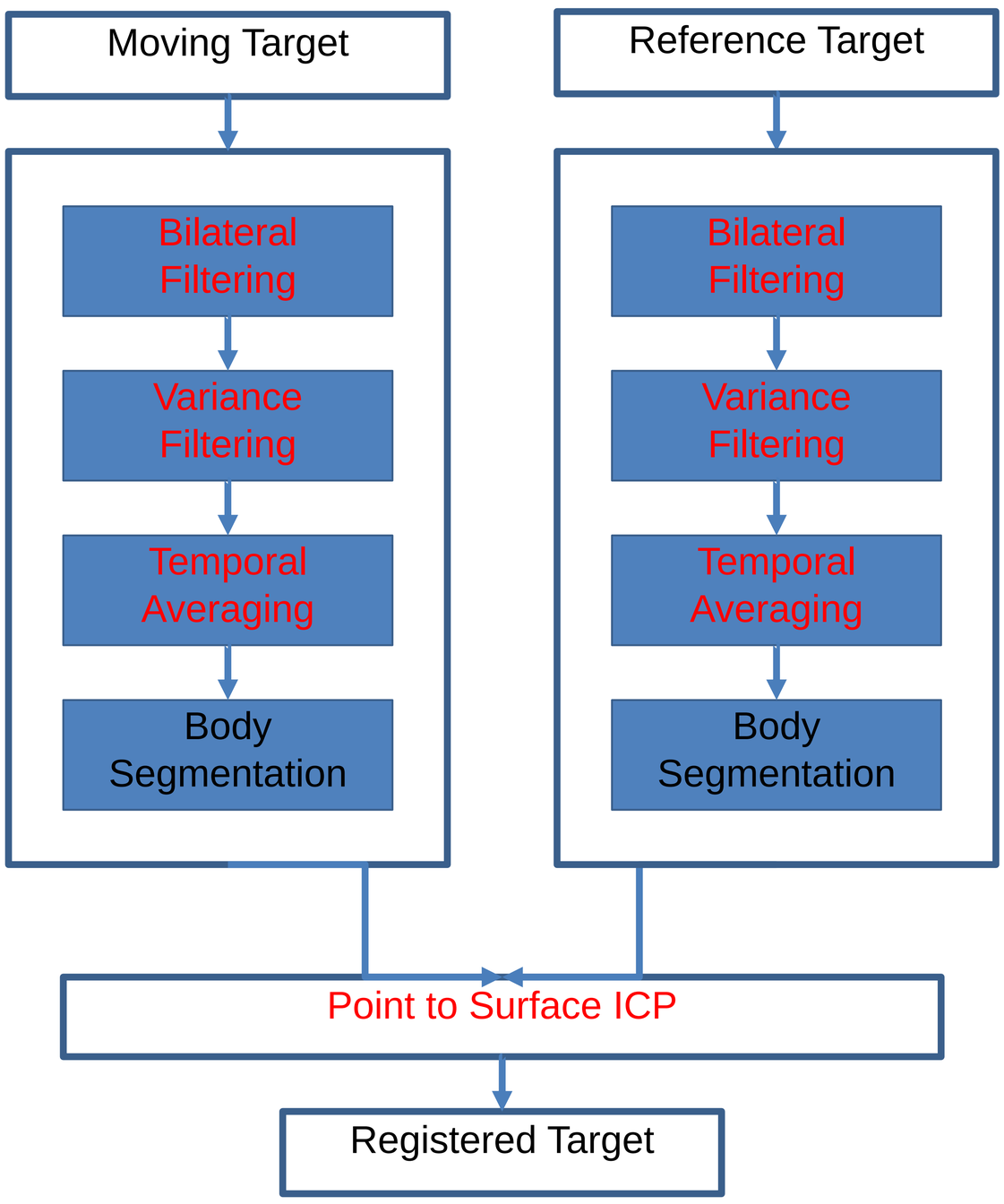

Fig 1. The processing pipeline for rigid body surface registration

Important improvements:
- Spatial noise reduction with Bilateral filter
- Removal of flying pixels by eliminating points with high temporal distance variances
- Avoidance of snap-to-grid effect by utilizing a point-to-plane distance measure in the Iterative Closest Point algorithm

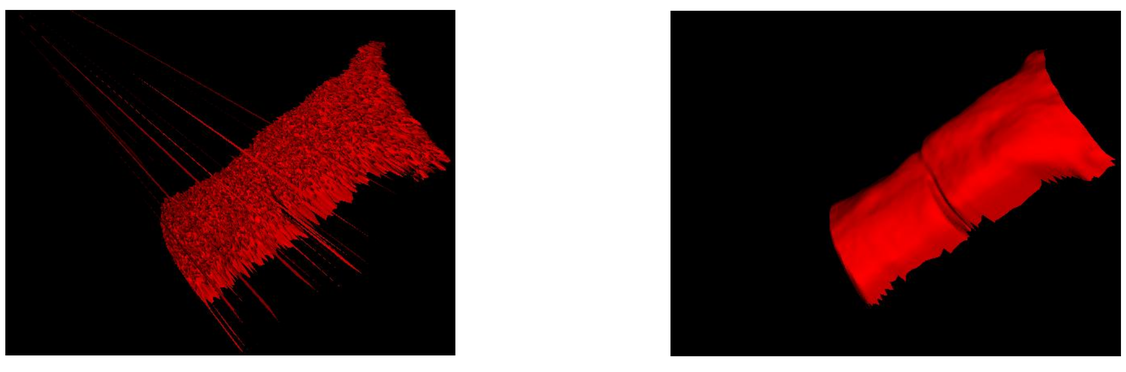

Fig 2. Left: Unfiltered body surfaces; Right: Preprocessed body surface

- Evaluation on a Siemens ONCOR treatment table
- Verification of true translations with gauges (range: 1 cm, accuracy: 0.01 mm)

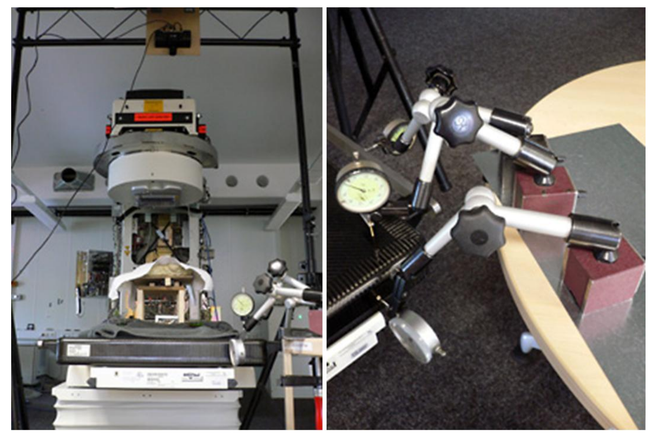

Fig 3. Left: Test setup; Right: Gauges to detect exact table displacement

Results

- Processing time: 1 fps on a 2.0 GHz dual-core CPU
- Reduction of positioning error from 2.88 mm ± 1.84 mm [2] to 0.74 mm ± 0.37 mm at a working distance of 150 cm:

	X-translation	Y-translation	Z-translation
min [mm]	0.17	0.00	0.10
max [mm]	1.88	1.46	1.37
mean [mm]	0.65	0.81	0.83
median [mm]	0.63	0.74	0.83
std [mm]	0.33	0.49	0.31

Tab 1. Statistics of registration results

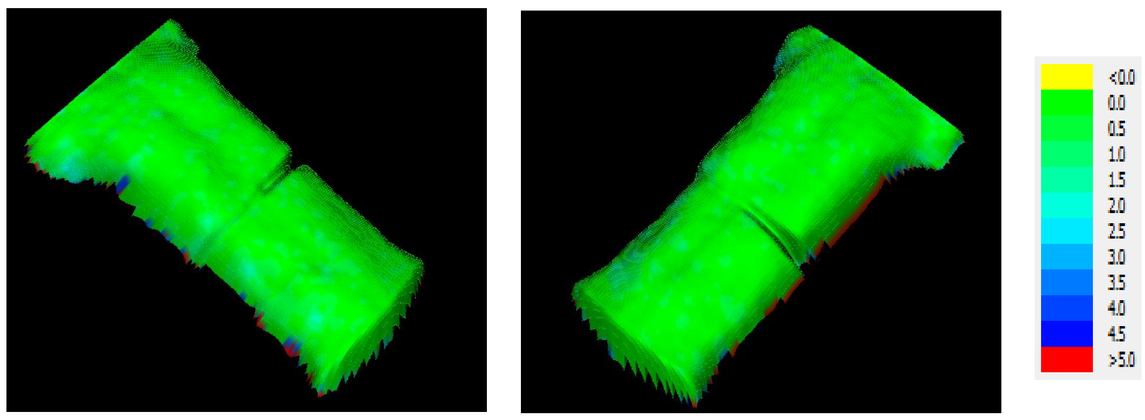

Fig 4. Color coded registration accuracy (surface distance)

Discussion

- For small translations the ToF based system is close to the medical accuracy requirements of 1 mm
- Current research projects consider also translations > 1 cm and table rotations
- Validation of a pre-registration step for large displacements

[1] Moore CJ, Graham PA. *3D Dynamic Body Surface Sensing and CT-Body Matching: A Tool for Patient Set-Up and Monitoring in Radiotherapy,* Computer Aided Surgery. 2000;5(4):234-45.

[2] Schaller C, Adelt A, Penne J, Hornegger J. *Time-of-flight sensor for patient positioning.* In: Samei E, Hsieh J (Eds.). Proceedings of SPIE. Vol 7258; 2009.