Robust sensorless reconstruction of the probe movement for freehand 3D echography

Loïc TETREL
McGill / Ecole de technologie supérieure
ECSE-626
loic.tetrel@mail.mcgill.ca

1. Introduction

3D echography is a challenging task and has been more and more studied nowadays. I'm studying a novel approach for the 3D registration of the images in my research since January 2015. That's why this course project can be in resonance with my work and can extend it.

2. Method

Sensorless 3D echography can be divided in 3 main steps :

1. Registration of all pair of frames using a specific feature (speckle for example) in the echographic images
2. Reconstruction of the freehand probe's movement combining the frame-pairs motion
3. 3D reconstruction of the echographic volume using the estimated movement

Because the article is huge, I will implement a part of the approach of Housden *et al.* [3].
Why this article ? Housden *et al.* gives a good summarizing of all previous method in sensorless registration for 3D echography, and since this date they remain a reference in the domain. We know that there is a correlation of the speckle between the echographic images [4], this allowed to extract the parameter z of the motion using the correlation. Using this information it is possible to estimate the global motion between two images. For this project I will focus more specificely the "speckle-decorrelation", "Frame selection" and "Intersecting frames".

1. They first acquire the echographic images with a robotic arm, and extract the speckle-decorrelation curve. "speckle-decorrelation"
2. They divide the images into a 8 column x 12 row grid of patches and estimate the (x_i, y_i, z_i) for each patch i using their previous work [2].
3. With the information (x_i, y_i, z_i) they construct the set of coarsly spaced frames. "Frame selection"
4. With a RANSAC algorithm they detect the patch outliers and the intersections of frames. "Intersection detection"
5. Finally, a least-squares fit method (Procustes) with all the remaining patches i is used to compute the global motion between two images.

To simplify the problem, we will reconstruct the coarsely spaced frames $[0, i, j]$ using the formula :

$$M_i^0 = M_j^0 \times m_j^i \tag{1}$$

3. Experimentation

I have access to various acquisitions of rigid monotonic freehand data (mostly in the z axis) on a phantom so I will not test the algorithm on real data. To validate my study, I will implement the mean target registration error introduced by De Kraats *et al.* [1] wich gives a good approximation of the registration error. I will compare my results with the result of their article Housden *et al.* using different acquisitions.

References

[1] E. B. De Kraats, G. P. Penney, D. Tomaževič, T. Van Walsum, and W. J. Niessen. Standardized evaluation methodology for 2-d-3-d registration. *Medical Imaging, IEEE Transactions on*, 24(9):1177–1189, 2005.

[2] R. J. Housden, A. H. Gee, G. M. Treece, and R. W. Prager. Subsample interpolation strategies for sensorless freehand 3d ultrasound. *Ultrasound in medicine & biology*, 32(12):1897–1904, 2006.

[3] R. J. Housden, A. H. Gee, G. M. Treece, and R. W. Prager. Sensorless reconstruction of unconstrained freehand 3d ultrasound data. *Ultrasound in medicine & biology*, 33(3):408–419, 2007.

[4] R. F. Wagner, S. W. Smith, J. M. Sandrik, and H. Lopez. Statistics of speckle in ultrasound b-scans. *Sonics and Ultrasonics, IEEE Transactions on*, 30(3):156–163, 1983.