curac2004
3. Jahrestagung der Deutschen Gesellschaft für Computer- und Roboterassistierte Chirurgie e.V.

Rigide Multimodale Registrierung ohne Marker
Rigid Multimodal Registration without Markers

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Introduction

Radiation therapy and many interventional techniques require real-time or at least sub-second control of patient motion. Often this information is obtained by point-pair matching with markers either attached on the skin surface or fixed in bone. In the case of X-ray fluoroscopy acquired images would already suffice to determine this motion.
Viola [1] suggests using randomly chosen samples of the image, Parzen-window estimation of the bimodal histogram estimation yielding a gradient, and a gradient based optimizer. He leaves the open questions how to choose the sample size and how to tune the stochastic optimizer.

Material and Methods

In our MICCAI paper [2] we introduce a direct method for choosing the sample size for the 2D-2D rigid registration problem without the need for costly test runs. We have defined a reference gradient and estimated the percentage of samples giving a gradient pointing into the same direction.
In our tests we have found that the sample size that estimates closest to 75% is near the optimum. Now we apply this approach to the 3D-3D rigid matching problem. The main difference is that we have 6 degrees of freedom for the transformation instead of three. For this problem the optimal sample size corresponds to an estimated percentage of 70. We also use a multiresolution approach to increase the capture range.

Results

We did 3D-3D experiments with an artificial MR pair obtained from brainweb (ICBM), correcting starting errors of 5-10 degrees and 5-10 voxels in 1.2-2.1 seconds.

Another test was done with a CT pair of a thigh, with contrast agent injected in one of the volumes. We corrected starting errors of 5-10 degrees and 5-10 voxels in 0.6-1.2 s. A third test was done with CTs of the lower leg, again with and without contrast agent in the blood vessels. The matching times were 0.6-1.4 s for 3-6 degrees and 3-6 voxels.
The CTs were provided by the Mannheim Klinikum. All testing was done on a PC with an Athlon 800 MHz processor. During our trials with different stochastic optimizers we observed that Resilient Backpropagation (Rprop) worked better than straight gradient ascent in terms of speed and accuracy. Stochastic conjugate gradient performed worst.

Discussion

The optimal sample size can be estimated in less than two seconds for most data sets. We have found that Rprop is easier to handle than straight gradient ascent because less parameters (gain sequence) have to be chosen to get good results. Our computation of reference gradients produces a probability of going into the „right" direction at each test pose. This information helps finding the optimal gain parameters for Rprop by simulating the optimization process.

Bibliography

[1] P. Viola. Alignment by Maximization of Mutual Information. PhD-Thesis, Massachusetts Institute of Technology, 1995.
[2] U. Müller et al. Fast Rigid 2D-2D Multimodal Registration. To appear in MICCAI 04, LNCS, Springer Verlag, 2004.