

Abstract of: **A new technique for multi-modal 3D image registration**

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Registering intraoperative ultrasound (US) to preoperative images like computed tomography (CT) or magnetic resonance (MR) remains a challenging problem in the field of image guided surgery. For many surgical applications, ultrasound provides adequate clinical information to carry out the required intervention. There are some applications, however, where being able to interpret the ultrasound images in the context of the higher quality preoperative imaging has been shown to be helpful.

Several techniques for the rigid registration of multi-modal images have been developed; in one of those the Kullback-Leibler distance (KLD) between the observed joint intensity distribution, and a reference distribution representing the prior knowledge of the expected joint intensity histogram when the images are aligned properly is used to align 2D-3D angiographic images. In this paper we investigate the performance of this technique on the registration of pairs of 3D CT/US images. We study the effects of various image perturbations on the performance of the registration, and obtain promising results.

To generate our test set, we used a 3D abdominal phantom (CIRS, Norwalk, VA). The CT scan (512x512, 1mm slices) was acquired using the Somatoform Plus4 (Siemens Medical Systems, Iselin, NJ). Two 3D US images of the liver (left lobe, right lower lobe) were generated using the Stradx software (Cambridge University, Cambridge, UK).

In order to study the robustness of the method against image variability we have perturbed the US images in various ways:

Geometrical distortion:

- we rescaled the image to 90 % of the original size in the x -direction

Brightness:

- we applied gamma-correction (with $\gamma = 0.5$) on the image to make it darker

Noise:

- we applied a Lee filter to the image, using a 7×7 window, and an estimated-noise-variance parameter of 250
- we applied a median filter to the image, using a 5×1 window. Visually this choice of the window size yields the best results regarding speckle suppression without blurring the image significantly

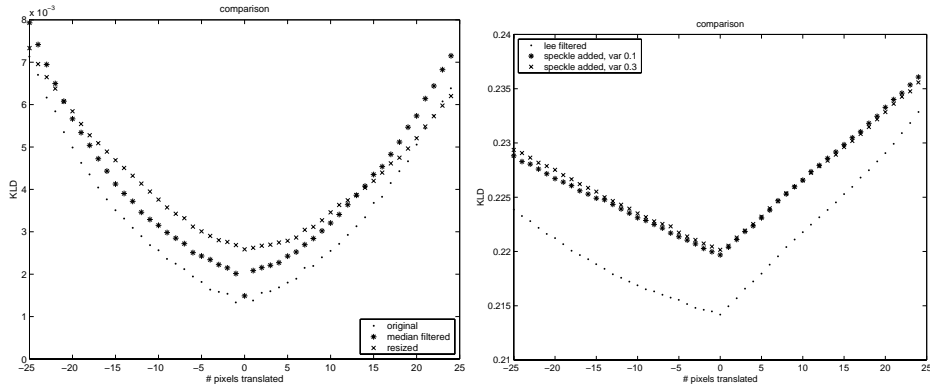


Fig. 1. KLD graphs of the perturbed images of the US image of the left lobe

- we added multiplicative (speckle) noise to the image artificially. If we call the image I , we added the noise using the equation $J = I + n * I$, where n is uniformly distributed random noise with mean 0 and variance 0.1 or 0.3

We wish to see the influence of these perturbations on the performance of the registration with respect to:

1. Accuracy
2. Speed of convergence
3. Robustness

As a measure of the accuracy we take the position of the minimum of the KLD graph. The speed of convergence and the robustness are estimated by the "pointedness" of the graph. We see in Figure 1 that in general, the shape of the KLD graphs is as follows: there is one global minimum, and in the direct neighbourhood of that the graph has a "V"-shape. With the "pointedness" of the KLD graph we mean the acuteness of the angle of this "V".

Figure 1 show us the KLD graphs of the various preprocessed images.

More results and their discussion can be found in the full paper.

We conclude that the proposed technique successfully succeeds in aligning the US-CT pair, also after the various perturbations of the US image. We are currently conducting further tests on human images to assess its suitability for clinical application.

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