Mutual Scale

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Abstract. Intensity-based registration of dynamic imaging data (for example for motion correction of contrast-enhanced MRI) or multi-modal fusion requires the use of a correlation measure that has good photometric invariance properties. We suggest that scale-localized image reconstruction prior to registration (based on the feature saliency of the images to be registered) often produces a better first estimation of a transformation, particularly if intensity conservation is assumed.

Introduction

The motion correction of dynamic soft-tissue imaging (e.g. breast MRI with Gd chelate) and multi-modal fusion (e.g. US-MRI, CT-PET) has lead to the development of registration techniques based on various forms of optical flow or correlated block matching algorithms [1-4]. Many of these algorithms are based on the fundamental assumption that intensities are conserved (in some suitable sense) in order to calculate a displacement field, although in practice, many model-based correction and regularization techniques are used to improve displacement field estimation.

The Mutual Scale Concept

Our hypothesis is that when computing a displacement or motion field between images, significant advantages accrue from using mutually scale-salient representations of the images to be registered. By this, we mean that the images to be registered should first be decomposed into a multi-scale representation and then reconstructed using:

- Scales which best reflect the information content of the images to be registered
- "Mutual Scales" in which *both* images to be registered are well represented.

A demonstration of the concept of image reconstruction at mutual scales is illustrated in Figure 1. In this figure, a breast MRI proton density image (TE=4.2ms, TR=8.9ms, $\alpha=3^{o}$) is compared with a T1-weighted ($\alpha=10^{o}$) image of the same slice. In this case, the intensity transformation is highly non-linear although a number of features remain visually consistent. We illustrate the reconstruction of the image pair at 3 different levels of scale (for example, using a wavelet-based approach, though the precise mechanism for computing the scale space is not the main point of this article). It is evident that most of the intensity transformation is localized at coarse scales (B,F), whilst at finer scales, it is possible to reconstruct a visually similar image via a suitable mutual scale.

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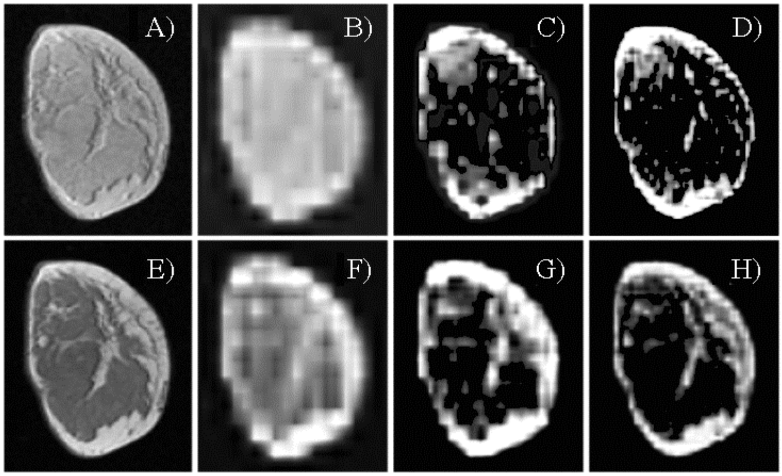

Fig. 1. A) and E) are the original images for which there is a non-linear intensity transformation. B) and F) are "coarse" scale examples which illustrate that the major component of the intensity transformation is localized to a low level of scale. C),G) and D),H) are reconstructions at successively finer scales. The pair D) & H) are a good example of reconstruction at a mutually salient scale.

The concept presented in this short paper is preliminary, however we feel that it demonstrates an inherently intuitive concept that appears not to have been noted before; but which forms the basis of many "workarounds" in image registration. One might argue that the notion of a mutual scale for image registration is simply a form of adaptive denoising or intensity correction. Our hypothesis is that an arbitrary registration approach is more meaningful when the feature scale for matching is appropriately addressed.

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