A DFT and Opto-Electronic Implementation of the Decoupled Automated Rotational and Translational (DART) Image Registration Algorithm

Image registration is an important tool in medical image analysis, particularly in functional MRI (fMRI) Common methods of registering two images designates one image as a reference and then iteratively shifts and rotates the test image to minimize some cost function. These methods are predominantly restricted to image domain processing. Maas et al published a frequency domain algorithm (DART) that determines translational and rotational parameters in a single pass. This algorithm incorporates several cross-correlation steps, utilizing a total of seven 2D FFTs and two 2D rectangular to polar. Sub pixel accuracy is obtained by zero filling the original images, however, the number of calculations for a 2D FFT goes up as $2n^2\log(n)$ and hence, greater precision is gained at the cost of dramatically increased processing time.

We have in our lab an opto-electronic processor called the ImSyn (Essex corporation - Columbia, MD) that performs a 128x128 complex DFT of non-rectilinear data in as little as 25 msec. Additional input parameters, X- and Y-axis scaling, X- and Y-axis shifting and a rotation angle, do not slow the transform speed. It is possible to perform a DFT on polar data without first interpolating onto a rectilinear grid. Using appropriate scaling and shifting factors, cross-correlations can be obtained with effective resolution of a 4096x4096 grid. We will present results on simulated phantom data and actual fMRI data sets.

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