2.2 Fourier transform

The Fourier transform (FT) of a function f(x,y) is defined as:

\[ F(u,v) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} f(x,y) e^{-j2\pi(ux+vy)} dx dy \]

or in frequency domain:

\[ F(u,v) = \mathcal{F}[f(x,y)] = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} f(x,y) \delta(t-\tau) \delta(t-\sigma) \exp(-j2\pi ft) dt \delta (t-t_0) dt_0 \]

where \( \mathcal{F} \) denotes the Fourier transform.

2.3 Phase-correlation-based method

The phase correlation method is based on the cross-correlation of the real part of the Fourier transforms of the two images. The correlation coefficient is given by:

\[ \rho = \frac{1}{S} \sum_{i,j} \frac{(Re \{ F(u,v) \}) (Re \{ F(u',v') \})}{\sum_{i,j} Re \{ F(u,v) \} Re \{ F(u',v') \}} \]

where S is the area of the image. The optimal shift is given by:

\[ (x_0, y_0) = \text{argmax} \rho(u,v) \]

2.4 Subpixel accuracy

To get the subpixel accuracy, one can use the cross-correlation method. The cross-correlation between the two images is maximized.

\[ CC_{x,y}(\Delta x, \Delta y) = \int f(x,y) g(x+\Delta x, y+\Delta y) dx dy \]

The cross-correlation can be calculated by:

\[ CC_{x,y}(\Delta x, \Delta y) = \mathcal{F}[f(x,y) g(x+\Delta x, y+\Delta y)] \]

The accuracy is given by:

\[ \Delta = \text{argmax} CC_{x,y}(\Delta x, \Delta y) \]

2.5 Data set and accuracy assessment

The methodologies were tested on a data set consisting of 10 pairs of plantar pressure images with dimensions of 45x63 pixels. Two kinds of experiments were done: in the first one, the accuracy was assessed by comparing the geometric transformation estimated by the registration algorithms with the control geometric transformation applied to the images. In the second experiment, the accuracy was assessed by computing the mean squared error (MSE) after registration with the MSE reported in previous studies. In both experiments, the involved geometric transformations were unknown.

REGISTRATION OF PEDOBAROGRAPHIC DATA SETS IN FREQUENCY DOMAIN

2.6 Implementation

The algorithms were implemented in C++, using Microsoft Visual Studio 6 and tested on a notebook PC with an AMD Turion 2.0 GHz microprocessor, 1.0 GB of RAM and running Microsoft Windows XP.

Table 1: Comparison between the control geometric transformation applied to 100 pedobarographic images and the corresponding geometric transformation estimated by the algorithms presented. (SD - Standard deviation, Tx - Translation along x axis, Ty - Translation along y axis)

<table>
<thead>
<tr>
<th>METHOD</th>
<th>MSE</th>
<th>Time [ms]</th>
<th>Tx</th>
<th>Ty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Register</td>
<td>0.12</td>
<td>12.3</td>
<td>0.05</td>
<td>0.1</td>
</tr>
<tr>
<td>C-based</td>
<td>0.01</td>
<td>2.3</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>N-based</td>
<td>0.03</td>
<td>2.3</td>
<td>0.02</td>
<td>0.01</td>
</tr>
</tbody>
</table>

REFERENCES


Aknowledgments:

The first author would like to thank his PhD grant from Fundação Calouste Gulbenkian in Portugal. This work was partially done under the scope of project PE/CT/5330/2008, PATATAT/MAT/009/2008 and PATATAT/CA/004/2008 supported by Fundação para a Ciência e a Tecnologia in Portugal.