Datacompression Using Wavelets

W. Mühlmann, A. Hanslmeier
INSTITUT FÜR ASTRONOMIE, UNIVERSITÄTSPLATZ 5, 8010 GRAZ, AUSTRIA

Spectra and images of solar granulation contain a large amount of information and need therefore much memory and disk space. Normal image compression techniques try to compress an image by encoding structures into bits. The Wavelet transform is a technique that finds out the predictable information of a picture or dataset by a simple matrix multiplication.

Like the FFT the Wavelet transform (DWT) is a very fast linear and orthogonal transform that operates on a vector of length \(2^n\). In contrary to the FFT the DWT is able to localize the frequencies. The coefficients for the DWT were first found out by I. Daubechies [1] in the 1980's, the simplest transform, the so called DAUB4, is performed by the following matrix:

\[
\begin{bmatrix}
  h_0 & h_1 & h_2 & h_3 \\
  h_3 & -h_2 & h_1 & -h_0 \\
  h_0 & h_1 & h_2 & h_3 \\
  h_3 & -h_2 & h_1 & -h_0 \\
  \vdots & \ddots & \ddots & \ddots \\
  h_0 & h_1 & h_2 & h_3 \\
  h_3 & -h_2 & h_1 & -h_0 \\
  h_2 & h_3 & h_0 & h_1 \\
  h_1 & -h_0 & h_0 & h_1 \\
\end{bmatrix}
\]

The inverse transform is simply the transposed matrix, because of the orthogonality. The odd lines of the matrix smooth the vector and the even ones point out differences between the points of the data vector. After the transformation a permutation is performed to order the new vector in such a way that the smoothed values are in the first half of the new vector. In the next step only the smooth part is transformed and then another permutation is done. This procedure is continued until only one smooth value remains.

Normally the values of the detail are some orders smaller than those of the smooth part. Therefore it is possible to neglect them and set them to zero. The inverse transformation of this new vector or array shows nearly no difference at all.

In an image of solar granulation about 95% of the values can be set to zero and the inverse transformed image shows only slight differences with maxima of 2%. The values, which are not zero, of the transformed image and their positions can be stored in a new file, which needs only 10 or less percent of the original file.