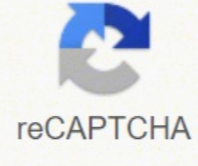




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First, visualize the Haar wavelet. open the main.m file and Run the program you will see GUI of Haar select browse for image and select a image of any dimension. The example employs a simple watermarking scheme chosen for ease of illustration. Cambridge, UK: Cambridge University Press, 2000. Haar wavelet transform (, MATLAB Central File Exchange. Peter Fleming, Dr Andrew Sawczenko, and Jeanine Young of the Institute of Child Health, Royal Hospital for Sick Children, Bristol and kindly provided for use in this example. This means that considering data over approximately two-week or even one-month periods is more accurate than data on smaller or longer scales. See Alsohaart | haart2 T. The sleep state data was scored based on the infant's EEG and EOG (eye movement) data, not based on the heart rate. Ullesh Chavadi M (2022). If the value is negative, the clock has lost time that day, a positive value means that the clock has gained time. Dashed lines on the plots delineate 95% confidence intervals for white noise inputs. This example features Haar lifting implementations which support integer-to-integer wavelet transforms for both 1-D and 2-D data and multichannel (multivariate) 1-D data. Statist. In other words, are there certain scales where the clock agrees most closely with the master clock? Walden, P., R. As an example, consider the relationship between heart rate and sleep state.Create Signal ApproximationsThe data consist of two time series. This example is essentially a recreation of the analysis presented in Percival & Walden [3], pp 13-16.load clock_571; figure; plot(clock_571) xlabel('Days') grid on; title('Daily Average Fractional Frequency Deviates - Cesium Clock'); The data are daily average fractional frequency deviates for a particular cesium beam atomic clock with respect to the U.S. Naval Observatory master clock. Plot the autocorrelation sequence of the original data along with the autocorrelation of the wavelet coefficients by scale for scales of 2,4,8,16, and 32 days. Because of these properties, you can make meaningful inferences based on the proportion of signal energy captured by the wavelet coefficients at each scale.scales = 2.^(1:6); figure plot(scales,energyByScale,'-o') xlabel('Scale (days)') set(gca,'xscale','log') set(gca,'xtick',2.^(1:6)) ylabel('Proportion of Signal Energy') grid on You see that the energy is at a minimum for scales of 16 and 32 days. B., and A. Retrieved May 24, 2022. Volume 63, No. 2, 2001, pp. To run all the code in this example, you must have Signal Processing Toolbox™ and Image Processing Toolbox™. Wavelet techniques in general and the Haar transform in particular are frequently employed in watermarking images. If the value of the time series is 0, that means the cesium clock has neither lost nor gained time with respect to the master clock over the duration of the day. Values exceeding those lines are indicative of significant autocorrelation in the data.[s,w] = haart(clock_571,6); helperAutoCorr(clock_571,w); The top plot shows the autocorrelation sequence for the original data. Read in the Mandrill image. Because the Haar transform provides a staircase approximation to a signal, it is often useful in situations where a response is dependent on a predictor variable with a small number of discrete states. The sleep state codes are 1=quiet sleep, 2=between quiet and active sleep, 3=active sleep, and 4=awake. Soc. This plot indicates scales over which the cesium clock is in best agreement with the master clock. For the Haar wavelet (and all Daubechies wavelets), the wavelet coefficients at a given scale represent differences between weighted averages of the data over a duration 1/2 the length of the scale. Subsequent plots show the autocorrelation sequences for wavelet coefficients at increasingly coarser scales. Here the discrete states are the four sleep stages. The Wavelet Toolbox™ supports Haar analysis in most of the discrete wavelet analysis tools. Next, demonstrate energy conservation.sigenergy = norm(clock_571,2)^2 energyByScale = cellfun(@(x)norm(x,2)^2,w); haarenergy = norm(s,2)^2*sum(energyByScale) sigenergy = 2.7964e+05 haarenergy = 2.7964e+05 The total signal energy is preserved by the Haar transform. The Haar transform is useful here because it possesses two important properties: It decorrelates data by scale and it partitions signal energy among scale.To illustrate the decorrelating property, obtain the Haar transform down to level 6. You can assess this change by looking at the correlation between the raw data and the sleep state time series.Now compare the value of 0.56 with the correlation between the sleep state data and the Haar approximation.The correlation has increased from 0.56 to 0.69. In this scheme, the watermark is inserted in the approximation coefficients at level 3.Watermark an image of a Mandril with one of a honey badger. This example illustrates the use of the Haar transform in watermarking an image and recovering the watermark. Resize it to 2048x2048 and display the result.coverIM = imread('mandrill.jpg'); coverIM = rgb2gray(coverIM); coverIM = imresize(im2double(coverIM),[2048 2048]); imagesc(coverIM) colormap gray title('Original Image to Watermark') axis off axis square Obtain the Haar transform of the Mandrill image down to level 3.[LLorig,LLHorig,HLorig,HHorig] = haart2(coverIM,3); imagesc(LLorig) title('Level 3 Haar Approximation') axis off axis square Read in watermark image and resize it.watermark = imread('honeybadger.jpg'); watermark = im2double(rgb2gray(watermark)); watermark = imresize(watermark,[2048 2048]); Obtain the Haar transform of the watermark image down to level 3.[LLw,LLHw,HLw,HHw] = haart2(watermark,3); imagesc(LLw) colormap gray title('Level 3 Haar Approximation-Watermark') axis off axis square Add the honey badger watermark to the Mandril image by attenuating the level-3 approximation coefficients of the watermark and inserting the attenuated coefficients into the level-3 Mandrill approximation coefficients.LLwatermarked = LLorig+1e-4*LLw; markedIM = haart2(LLwatermarked,LLHorig,HLorig,HHorig); imagesc(markedIM) title('Watermarked Image') axis off axis square colormap gray The watermark (honey badger) is not visible in the watermarked image. Wavelet Methods for Time Series Analysis, you can see only LL components of the Haar transform by clicking on "press for LL compents". Load and plot the clock_571 dataset. One time series is the heart rate of a 66-day old infant sampled every 16 seconds for just over 9 hours. As previously mentioned, this has important implications for geodesy where extremely precise time measurements are critical.Although the Haar wavelet is discontinuous, it is still effective at representing various kinds of time series. It is clear that the autocorrelation sequence of the original data exhibits correlation at all lags while the Haar transform coefficients are decorrelated. For this data, the values are all negative. Sapatinas, and A. Series B. Both time series were recorded by Prof. Volume 62, Issue 2, 2000, pp. "Wavelet processes and adaptive estimation of the evolutionary wavelet spectrum." J. 199-217.[3] Percival, D. The other time series is the expertly scored sleep state of the same infant over the same period with the same sampling rate. As a result, it is typically not used in denoising or compression applications where smoothness of the reconstruction wavelet is an important consideration. For certain applications, like geodesy, it is important to know whether there are certain time scales where the clock's deviation from the master clock is at its lowest value. Click on Press for haar, you can the transformed image with given pyramid. Sawczenko. "Wavelet packet modelling of infant sleep state using heart rate data." Sankhya: The Indian Journal of Statistics. R. Plot the heart rate data along with the sleep states.load BabyECGData figure yyaxis left plot(times,HR) ylabel('HR') xlabel('Hrs') YLim = [min(HR)-1 max(HR)+1]; yyaxis right plot(times,SS) ylabel('Sleep State') YLim = [0.5 4.5]; title('Baby ECG and Sleep State') An inspection of the data reveals an apparent correlation between sleep state and heart rate, but the data is extremely noisy. It is a passive protection technique where a marker is covertly inserted in some data in order to verify the authenticity or integrity of the data. This example shows how to use Haar transforms to analyze time series data and images. P., T. This program gives the out put of the Haar 2D transform. Plot the result.[S,W] = haart(HR,'integer'); HaarHR = haart(S,W,5,'integer'); figure hL = plotyy(times,HaarHR,SS); Ax1 = hL(1); Ax2 = hL(2); Ax1.YLim = [min(HaarHR)-1 max(HaarHR)+1]; Ax1.YLabel.String = 'HR'; Ax2.YLim = [0.5 4.5]; Ax2.YLabel.String = 'Sleep State'; xlabel('Hrs') title('Haar Approximation and Sleep State') The Haar approximation more clearly shows the relationship between the sleep state and the heart rate data. von Sachs, and G. Because the heart rate data is integer-valued, use the 'integer' flag to ensure that integer-valued data is returned. 271-292.[2] Nason, G. Examples include count data and data where values of a time series are tied to some specific state, which affects the level of the time series. Because you know what algorithm was used to insert the watermark, you can recover the watermark using the Haar transform.[LLr,LLHr,HLr,HHr] = haart2(markedIM,3); LLmarked = (LLr-LLorig)*1e4; imagesc(LLmarked) title('Recovered Watermark') colormap gray axis off axis square [1] Nason, G. More advanced wavelet analysis and modeling of this data is presented in Nason, von Sachs, & Kroisandt [1] and Nason, Sapatinas, & Sawczenko [2].Digital Watermarking of ImagesWatermarking is an important data protection tool. The heart rate time series is integer-valued. Kroisandt. However, Haar transforms are useful in a number of applications due to their superior time (spatial) localization and computational efficiency. Obtain the Haar approximation of the heart rate data using a level 5 approximation. [-,psi,x] = wavefun('haar',10); x = x(2:end-1); psi = psi(2:end-1); hl = plot(x(1:512),psi(1:512)); grid on hold on line(x(513:end),psi(513:end)) xlabel('t') ylabel('psi(t)') title('Haar Wavelet') The Haar wavelet is discontinuous.

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