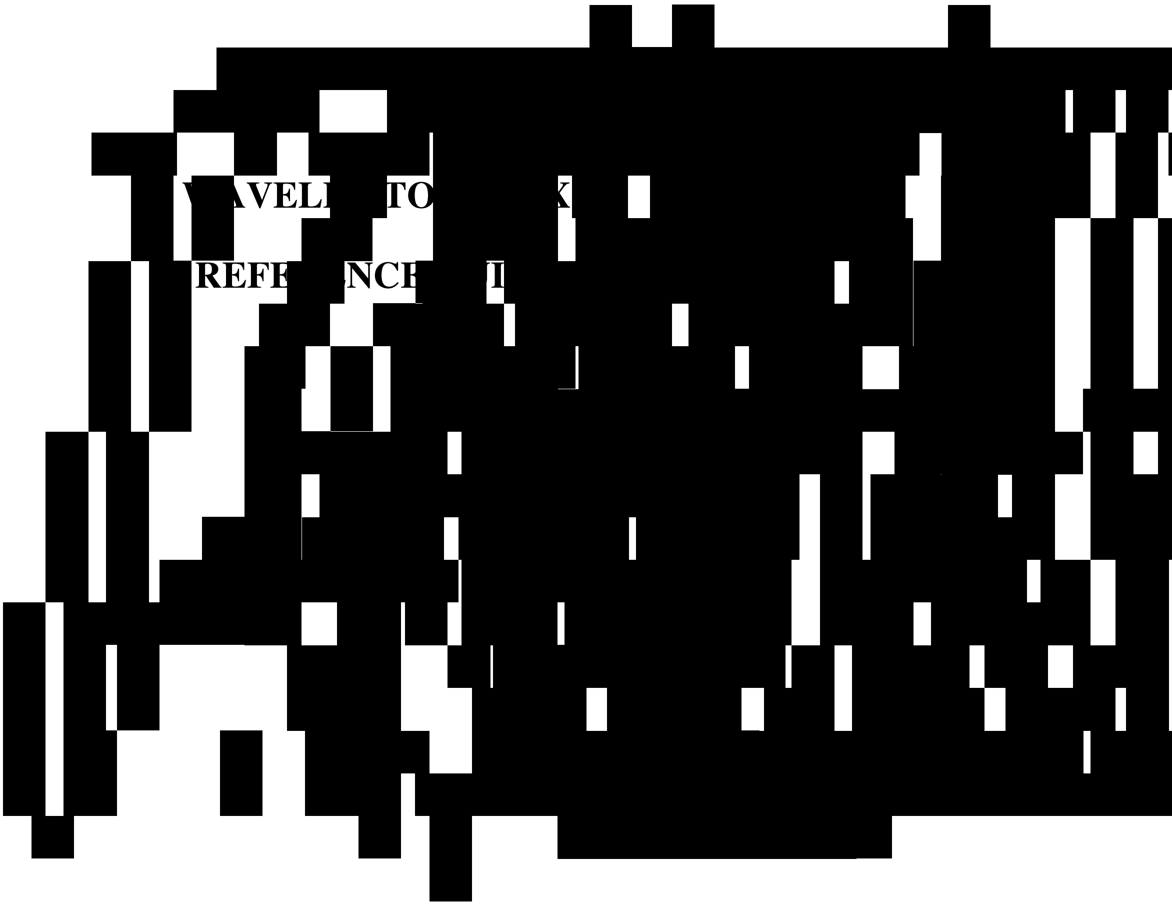
GDR 134

GROUPEMENT DE RECHERCHE
TRAITEMENT DU SIGNAL ET IMAGES



CONTENTS

Visualization

visu : Visualizes intensity pixels.
visuerr : Visualizes error image.

Coding Tools

polish : Polish image data for output.
histogram : Plot histogram or compute pdf.
entropy : Zero-th order entropy.
huffmann : Global huffmann coding rate.
snr : Signal to noise ratio.

2D Wavelet Transformation

Periodic wavelet transform

psplit2 : One step of wavelet analysis.
pmerge2 : One step of wavelet synthesis.
pdwt2 : Wavelet transform.
pidwt2 : Inverse wavelet transform.

Miscellaneous

sub : Select subimage.
wvisu : Visualize wavelet coefficients.

Quantization

wq : Quantization of wavelet coefficients.
iwq : Inverse quantization of wavelet coefficients.

Coding

wbitrate : Total bitrate of wavelet coefficients.

Optimal bit allocation

rdoptim : Rate/Distortion optimisation of quantizers.
rdoptim1 : Initialisation for rdoptim.

Image Quantization

sq : Uniform scalar quantization
isq : Inverse uniform scalar quantization

Image Database (.mat files)

256 x 256 images

angiography :	GDR "angiographie".
corridor :	GDR "couloir".
crossroad :	GDR "carrefour", coded on 7bpp.
desk :	GDR "bureau".
lady :	The famous LADY image.
lena256 :	The famous LENA or GIRL image.
muscles :	GDR "muscles".
rings :	GDR "bagues".

512 x 512 images

bridge :	BRIDGE.
benoit :	BENOIT child.
lena512 :	LENA, used by the GDR.
lena512bis :	LENA, used by some american authors.
mandrillbw :	MANDRILL, converted from color image.

576 x 720 images

barbara :	J-PEG standard.
boats :	J-PEG standard (also called CORNOUAILLE).
zelda :	J-PEG standard.

Wavelet Toolbox Demonstrations

imgdemo :	Visualization of b&w images
wavdemo :	Wavelet design tools
wtdemo :	Wavelet transformation on images
rddemo :	Optimal bit allocation (in a rate/distortion sense) of wavelet coefficients.

Digital Signal Processing Tools

Contents

Graphics

Design

allres

Purpose

Plot all responses

Synopsis

allres(H)

Description

allres creates a figure that allows the user to plot impulse, magnitude, phase, group delay responses and zero plot of any FIR filter interactively.

See also

IMPRES, MAGRES, PHASERES, GDRES, ZPLOT in the GDR Wavelet Toolbox.

Author

Olivier Rioul, March 1994

gdres

Purpose

Group delay response

Synopsis

gdres(H1)

gdres(H1,H2,H3,H4,H5,H6,H7,H8,H9)

Description

gdres(H) plots the group delay response of FIR filter H. If H is a matrix, then multiple responses are plotted for each line.

gdres(H1,H2,...) is another way of producing multiple responses on the same plot, except that filters may have different lengths.

Algorithm

The group delay response is computed using the following formula:

$$G_d(w) = -\frac{d(\arg(H(w)))}{dw}$$

See also

ALLRES, PHASERES in the GDR Wavelet Toolbox.

Author

Olivier Rioul, March 1994

impres

Purpose

Impulse response

Synopsis

impres(H)

impres(H1,H2,...)

Description

impres(H) plots the FIR filter coefficients H as 'stems' from the x-axis. If H is a matrix, then multiple responses are plotted for each line.

impres(H1,H2,...) is another way of producing multiple responses on the same figure, except that filters may have different lengths.

See also

STEM in the standard MATLAB Toolbox and ALLRES in the GDR Wavelet Toolbox.

Author

Olivier Rioul, March 1994

magres

Purpose

Magnitude frequency response

Synopsis

magres(H)

magres(H1,H2,...)

magres(...,'dB')

magres(...,'dB2')

magres(square(H),'dB2')

magres(...,dBmin)

Description

magres(H) plots the magnitude frequency response of FIR filter H using linear y-axis scale. If H is a matrix, then multiple responses are plotted for each line.

magres(H1,H2,...) is another way of producing multiple responses on the same plot, except that filters may have different lengths.

magres(...,'dB') plots magnitude response(s) in dB, assumingpass-band gain =1.

magres(...,'dB2') assumes filter(s) are convolutional squares:

magres(square(H),'dB2') is equivalent to MAGRES(H,'dB')

magres(...,dBmin) selects plot in dB and sets dBmin<0 as the minimum attenuation shown on the figure. Default is dBmin=-40dB.

See also

ALLRES, SQUARE in the GDR Wavelet Toolbox.

Author

Olivier Rioul, March 1994

mirror

Purpose

Mirror filter design

Synopsis

mirror(H)

G=mirror(H)

Description

mirror(H) is the 'mirror' filter of FIR filter H. It applies linewise if H is a matrix

Algorithm

Given a low-pass (high-pass) FIR filter h whose length is L. Its high-pass (low-pass) FIR mirror filter is given by

$$g(n)=(-1)^n h(L-1-n), n=0,1,...L-1.$$

Author

Olivier Rioul, March 1994

phaseres

Purpose

Phase frequency response

Synopsis

phaseres(H)

phaseres(H1,H2,...,H9)

Description

phaseres(H) plots the phase frequency response of FIR filter H. If H is a matrix, then multiple responses are plotted for each line.

phaseres(H1,H2,...) is another way of producing multiple responses on the same plot, except that filters may have different lengths.

See also

ALLRES, GDRES in the GDR Wavelet Toolbox.

Author

Olivier Rioul, March 1994

phasevar

Purpose

Phase variation of half-band FIR filter

Synopsis

phasevar(H)

Description

phasevar(H) gives total group delay variation of FIR half-band low-pass or high-pass filter H in the pass-band. It is a (positive) measure of phase distortion between 0 and L-1 (samples). If it is 0, then H is linear phase. Check the result with GDRES. If H is a matrix, phasevar(H) is a column vector containing the group delay variation for each line.

See also

PHASERES, FACTOR, GDRES in the GDR Wavelet Toolbox.

Author

Olivier Rioul, March 1994

square

Purpose

Convolutional square

Synopsis

p=square(H)

Description

square(H) is the convolutional square of FIR filter H, whose phase response is linear. Applies linewise if H is a matrix

Author

Olivier Rioul, March 1994

zplot

Purpose

Plots zeroes of FIR filter H in the complex plane

Synopsis

zplot(H)

zplot(H1,H2,...,H9)

Description

zplot(H) plots zeroes of FIR filter H in the complex plane. If H is a matrix, then zeroes are plotted for each line.

zplot(H1,H2,...) is another way of producing multiple zero plots on the same figure, except that filters may have different lengths.

See also

ALLRES in the GDR Wavelet Toolbox.

Author

Olivier Rioul, March 1994

zremez

Purpose

Optimal Chebyshev filter design

Synopsis

[H,w]=zremez(L,K,B,dw,p,w)

Description

Given number of taps L, flatness order K (number of zeros at z==-1), normalized transition bandwidth B, transition bandwidth offset dw about 0.25 (positive or negative), and pass-band weight p=delta2/delta1, ZREMEZ(L,K,B,dw,p) gives a vector containing the coefficients of linear-phase FIR low-pass filter that is optimal in the Chebyshev sense for these specifications. Its mirror filter (see MIRROR) is the corresponding high-pass filter for the same specifications except that dw is changed to -dw.

[H,w]=zremez(...) gives access to alternance values w0, ..., wN in the grid 0:64*N.

zremez(L,K,B,dw,p,w) uses alternance values w as first guess.

Note : This program includes REMEZ in the Signal Processing Toolbox as a special case.

See also

MIRROR, REMEZWAV in the GDR Wavelet Toolbox.

Author

Olivier Rioul, March 1994

Wavelet Tools

Contents

Purpose

Bi-orthogonal Complement filter

Synopsis

Hp=co(H,K)

Description

co(H) is the bi-orthogonal complement filter of low-pass linear-phase L-tap filter H. Its length is L if L is even (type A) and L-2 if L is odd (typeB). Its pass-band gain is 2/g where g is the pass-band gain of H.

co(H,K) forces K zeros at z=-1 in the complement filter. Its length will be L+2*(K-1) where L is the length of H. CO(H) is equivalent to CO(H,0) if L is odd, CO(H,1) if L is even. In all cases, L-K must be odd.

Author

Olivier Rioul, March 1994

References

[1] Olivier Rioul, Ondelettes regulieres: Application a la compression d'images fixes, PhD Thesis, Telecom Paris, March 1993.

daub

Purpose

Daubechies filter

Synopsis

H=daub(L,type)

Description

daub(L) or daub(L,'min') produces the minimum phase Daubechies low-pass filter of length L.

daub(L,'lin') produces the Daubechies filter whose phase response is closest to linear (as determined by PHASEVAR).

Algorithm

In the frequency domain, the wavelet, ψ, is defined as

$$\psi(\omega)=H_1(e^{j\frac{\omega}{2}})\phi(\omega)$$

where

$$\phi(\omega)=\prod_{k=2} H_0(\frac{e^{j\frac{\omega}{2^k}}}{2})$$

is the scaling function. H_0 is the low-pass filter and H_1 is its high-pass mirror filter. Daubechies low-pass filter H_0 is designed such that it has the maximum number of zeros at z=-1.

See also

FACTOR, PHASEVAR, REMEZWAV, WFILTER in the GDR Wavelet Toolbox

Author

Olivier Rioul, March 1994

References

[1] Ingrid Daubechies, Orthonormal bases of compactly supported wavelets, Comm. Pure Appl. Math., Vol. XLI, No. 7, pp. 909-996, 1988.

[2] Ingrid Daubechies, Orthonormal bases of compactly supported wavelets II, Variations on a theme, SIAM J. Math. Anal., Vol. 24, 1993.

factor

Purpose

Zero factoring (Riesz lemma)

Synopsis

H=factor(Z,type)

Description

factor(Z) produces filter H by factoring the complex zeroes Z of the linear phase filter SQUARE(H) (as obtained by design routines). Zeroes in Z must have even multiplicity on the unit circle and be associated in (z,z*,1/z,1/z*) quadruples outside the unit circle. The resulting filter H is normalized such that NORM(H)=1. By default, selection of zeros (z,z*) or (1/z, 1/z*) for H is done manually by clicking the mouse on the screen.

factor(Z,'min') gives the minimum phase solution H

factor(Z,'max') gives the maximum phase solution H

factor(Z,'lin') gives the solution whose phase response is closest to linear (as determined by PHASEVAR).

factor(Z,'all') gives all solutions as lines of matrix H=[H0; H1; H2; ...] With the convention that indexes range from 0, Hn is designed by selecting zeros outside (1) or inside (0) the unit disk as absolute angle of zeros increases. For example, n=1011 in base 2 means (in reverse order): First outside, then outside, then inside, then outside. H0 is the minimum-phase solution, while last Hn (n=2^(..)-1) is the maximum-phase solution. Note that the second half of solutions are the time-reversals of the first half.

factor(Z,'allsorted') gives all solutions sorted from increasing PHASEVARs as lines of matrix H.

See also

PHASEVAR, REMEZWAV, MAGRES, SQUARE, ZPLOT in the GDR Wavelet Toolbox and NORM in the standard MATLAB Toolbox.

Author

Olivier Rioul, March 1994

References

[1] Mark J. T. Smith and Thomas P. Barnwell III, Exact reconstruction techniques for tree-structured subband coders, IEEE Trans. ASSP, Vol. 34, No. 3, pp. 434-441, 1986.

[2] Ingrid Daubechies, Orthonormal bases of compactly supported wavelets, Comm. Pure Appl. Math., Vol. XLI, No. 7, pp. 909-996, 1988.

[3] Olivier Rioul and Pierre Duhamel, A Remez exchange algorithm for orthonormal wavelets, IEEE Trans. CAS II, To appear.

Purpose

Hölder Regularity order of low-pass filter H.

Synopsis

r=reg(H,K)

Description

reg(H) gives a sharp upper bound for the Hölder regularity order of low-pass filter H (it may be negative).

reg(H,K) forces the number of zeros at z==-1 in H to K. By default, K is estimated by successive division with remainders <1e-3

Algorithm

In order to ensure that the infinite product (scaling function)

$$\phi(\omega)=\prod_{k=1} H_0(\frac{e^{j\frac{\omega}{2^k}}}{2})$$

converges to a smooth function rather than breaks into fractals, $H_0(\omega)$ should have some regularity, that is a certain number of continuous derivatives. The regularity is shown to increase with the number of zeros at z=-1. In reference [1], two technics are developped to compute this regularity: the Hölder regularity and the sobolev regularity.

See also

SOBREG in the GDR Wavelet Toolbox

Author

Olivier Rioul, March 1994

References

[1] Olivier Rioul, Simple regularity criteria for subdivision schemes, SIAM J. Math. Anal., Vol. 23, No. 6, pp. 1544-1576, Nov. 1992.

sobreg

Purpose

Optimal Sobolev regularity order of low-pass filter H

Syopsis

r=sobreg(H,K)

Description

sobreg(H) gives the optimal Sobolev regularity order of low-pass filter H (it may be negative).

sobreg(H,K) forces the number of zeros at z==-1 in H to K. By default, K is estimated by successive division with remainders <1e-3.

Algorithm

See REG in the GDR Wavelet toolbox

See also

REG in the GDR Wavelet Toolbox

Author

Olivier Rioul, March 1994

References

[1] Olivier Rioul, Simple regularity criteria for subdivision schemes, SIAM J. Math. Anal., Vol. 23, No. 6, pp. 1544-1576, Nov. 1992.

Purpose

Optimal wavelet generation using Remez exchange algorithm

Synopsis

[p,r,delta]=remezwav(L,K,B)

Description

remezwav(L,K,B) gives impulse response of maximally frequency selective P(z), product filter of paraunitary filter bank solution H(z) of length L satisfying K flatness constraints (wavelet filter). The normalized transition bandwidth is given as B. This argument is optional if K==L/2.

[P,R]=REMEZWAV(L,K,B) also gives the roots of P(z), which can be used to determine H(z).

[P,R,DELTA]=REMEZWAV(L,K,B) also gives maximum deviation, if K<L/2 (i.e., P(z) is between 0 and delta in stop band).

Algorithm

The algorithm of REMEZWAV is a generalization of the algorithm REMEZ we can find in Matlab Toolbox. It is developped in details in reference [1].

Author

Olivier Rioul, November 1992.

References

[1] Olivier Rioul and Pierre Duhamel, A Remez exchange algorithm for orthonormal wavelets, IEEE Trans. CAS II, To appear.

[2] Ingrid Daubechies, Orthonormal bases of compactly supported wavelets, Comm. Pure Appl. Math., Vol. XLI, No. 7, pp. 909-996, 1988.

[3] Mark J. T. Smith and Thomas P. Barnwell III, Exact reconstruction techniques for tree-structured subband coders, IEEE Trans. ASSP, Vol. 34, No. 3, pp. 434-441, 1986.

wfilter

Purpose

Orthonormal wavelet filter

Synopsis

wfilter(L,K,B)

wfilter(L,K,B,'min')

Description

wfilter(L,K,B) or wfilter(L,K,B,'min') produces the minimum-phase orthonormal wavelet low-pass filter of length L with K zeros at the Nyquist frequency (z==-1), and maximally frequency selective given normalized transition bandwidth B. (See REMEZWAV)

wfilter(L,K,B,'lin') produces the wavelet filter whose phase response is closest to linear (as determined by PHASEVAR)

wfilter(L,L/2,B,'type') is equivalent to DAUB(L,'type')

Algorithm

See DAUB in GDR Wavelet Toolbox

See also

DAUB, FACTOR, PHASEVAR, REMEZWAV from the GDR Wavelet Toolbox

Author

Olivier Rioul, March 1994

References

[1] Olivier Rioul and Pierre Duhamel, A Remez exchange algorithm for orthonormal wavelets, IEEE Trans. CAS II, To appear.

[2] Ingrid Daubechies, Orthonormal bases of compactly supported wavelets, Comm. Pure Appl. Math., Vol. XLI, No. 7, pp. 909-996, 1988.

[3] Mark J. T. Smith and Thomas P. Barnwell III, Exact reconstruction techniques for tree-structured subband coders, IEEE Trans. ASSP, Vol. 34, No. 3, pp. 434-441, 1986.

wlet

Purpose

Plots wavelets, scaling functions and their derivatives

Synopsis

wlet(H,iter,dn)

Description

wlet(H) plots scaling function or wavelet associated to filter H, if H is a low-pass or high-pass filter, respectively.

wlet(H,n) forces the number of iterations to n. By default, n is determined such that the curve has at least 200 points.

wlet(H,n,m) plots the m-th derivative of scaling function or wavelet (see above) using n iterations.

Author

Olivier Rioul, March 1994

Image Processing Tools

Contents

I/O functions

Visualization

Coding Tools

entropy

Purpose

Compute the 0th-order entropy of image I (in bits per pixel)

Synopsis

s=entropy(p)

Description

entropy(p) compute the 0th-order entropy of image I (in bits per pixel) (pre-calculation of its pdf is needed).

entropy(P) does the same given the pdf P of I (see HISTOGRAM).

See also

HISTOGRAM, HUFFMANN in the GDR Wavelet Toolbox.

Author

Olivier Rioul, March 1994

histo

Purpose

Performs the inner calculations used by HISTOGRAM.

Synopsis

n=histo(x,nn)

Description

performs the nner calculations used by HISTOGRAM.

Author

Olivier Rioul, March 1994

histogram

Purpose

Plot histogram of image or compute its pdf

Synopsis

p=histogram(I,flag)

Description

histogram plots histogram of image or compute its pdf.

histogram(I) returns the pdf P of image I (or any set of values), where P(i) is the percentage of pixels having value min(I)+i-1.

histogram(I,'plot') also plots the histogram of I.

Caution : The pixel values are first rounded to integers.

Author

Olivier Rioul, March 1994

huffmann

Purpose

Huffman coding

Synopsis

h=huffmann(p)

Description

huffmann(I) gives the number of bits per pixel obtained using a global Huffmann code (GHC) on image I (precalculation of its pdf is needed).

huffmann(P) does the same given the pdf P of I (See HISTOGRAM). It takes a few seconds when length(P)=256.

See also

ENTROPY, HISTOGRAM in the GDR Wavelet Toolbox

Author

Olivier Rioul, March 1994

polish

Purpose

Round to integers between 0 an 255

Synopsis

x=polish(x)

Description

polish(X) returns matrix or vector X with values rounded to integers between 0 and 255 (Values above 255 are rounded to 255 and negative values are rounded to 0).

See also

VISU in the GDR Wavelet Toolbox

Author

Gerard Yvon, March 1994

rawread

Purpose

Read a specified file

Synopsis

I = rawread(filename,N,Nskip)

Description

rawread('filename',[nl,nc]) reads specified file containing a matrix of nl*nc bytes in "raw" format (bytes stored line by line).

rawread('filename',nc) does not use information on the number of lines but reads until the end-of-file is reached.

rawread('filename',[nl,nc],nskip) or RAWREAD('filename',nc,skip) specify that a header of nskip bytes has to be skipped at the beginning of the file.

See also

RAWWRITE in the GDR Wavelet Toolbox.

Author

Gerard Yvon, March 1994

rawwrite

Purpose

Write bytes from a matrix to a filename

Synopsis

rawwrite(I,filename)

Description

rawwrite(I,'filename') writes bytes from matrix I to the specified filename in "raw" format (bytes stored line by line).

Caution: Values from matrix I must be POLISH'ed first.

See also

POLISH, RAWREAD in the GDR Wavelet Toolbox.

Author

Olivier Rioul, March 1994

snr

Purpose

Signal to Noise Ratio

Synopsis

r=snr(I,Ip)

Description

snr(I,IP) gives the signal to noise ratio in dB for original image I and processed image IP.

snr(I-IP) gives the Peak Signal over Noise Ratio (PSNR) when I is originally on 8 bits per pixel.

Author

Olivier Rioul, March 1994

visu

Purpose

Image visualization (gray levels)

Synopsis

visu(I,zm)

Description

visu(I) displays intensity pixels of image I on the bottom-left of the screen using gray colormap. By default, the image is displayed at the resolution of the screen. The image pixels are assumed to be encoded on 8 bits (from 0 to 255). It is a good idea to POLISH them first.

visu(I,zoom) specifies a zoom factor (magnifies if zoom>1). If zoom is negative, the image is displayed in reverse video. Popup menu 'zoom' specifies the resolution at which the image can be displayed: 'zoom 1' always sets back to the screen resolution. Popup menu 'local zoom n' allows to enable or inhibit the Matlab built-in function 'zoom'.

See also

POLISH, VISUERR from the GDR Wavelet Toolbox and ZOOM in the standard MATLAB Toolbox.

Author

Olivier Rioul, March 1994

visuerr

Purpose

Displays absolute values of intensity pixels of an "error image"

Synopsis

visuerr(x,zoom)

Description

visuerr(I) displays absolute values of intensity pixels of an "error image" I. The absolute values of pixels are fitted in the interval [black->white] (black correspond to zero).

visuerr(I,zoom) displays the "error image" with the specified zoom factor. If zoom is negative, the image is displayed in reverse video.

See also

VISU in the GDR Wavelet Toolbox

Author

Olivier Rioul, March 1994

2D Wavelet Transformation

Contents

Periodic wavelet transform

Miscellaneous

Quantization

Coding

Optimal bit allocation

iwq

Purpose

Inverse quantization of wavelet coefficients

Synopsis

Wq=iwq(fname,Wq,c)

Description

iwq('fname',Wq,c) rescales subimages (j,k) of wavelet matrix Wq after quantization, using scaling array c(j,k) (see SQ,ISQ) and quantizer 'fname' (see ISQ).

See also

ISQ, SQ in the GDR Wavelet Toolbox.

Author

Olivier Rioul, March 1994

pdwt2

Purpose

Orthonormal 2D separable wavelet transform with periodic extension

Synopsis

[I,J]=pdwt2(I,g,J)

Description

pdwt2(I,H,j) performs an orthonormal discrete wavelet transform (DWT) of image I on j levels ("octaves") using separable filters based on low-pass orthonormal (synthesis) filter H and periodic extension at the edges. The resulting matrix is the "canonical form" (see PSPLIT2).

pdwt2(I,H) does the wavelet decomposition with maximum number of levels j such that the image dimensions stay even and greater than the filter length. This j is returned as a second argument.

See also

PSPLIT2, PIDWT2 in the GDR Wavelet Toolbox.

Author

Olivier Rioul, March 1994

pidwt2

Purpose

Orthonormal 2D inverse wavelet transform with periodic extension

Synopsis

I=pidwt2(I,g,J)

Description

PIDWT2(W,H,j) performs an orthonormal inverse discrete wavelet transform (IDWT) of image W on j levels ("octaves") using separable filters based on low-pass orthonormal (synthesis) filter H and periodic extension at the edges. The input matrix W must be in the "canonical form" (see PMERGE2).

See also

PSPLIT2, PDWT2 in the GDR Wavelet Toolbox.

Author

Olivier Rioul, March 1994

pmerge2

Purpose

Periodic separable wavelet merge

Synopsis

I=pmerge2(I,g)

Description

pmerge2(I,H) performs one step of orthonormal wavelet reconstruction on the lines and columns of I, using low-pass orthonormal (synthesis) filter H and periodic extension at the edges. The input matrix must be in the form [low , vert ; horiz , diag] (see PSPLIT2).

See also

PMERGEC2, PIDWT2 in the GDR Wavelet Toolbox.

Author

Olivier Rioul, March 1994

pmergec2

Purpose

Periodic wavelet merge column by column

Synopsis

I=pmergec2(I,g)

Description

PMERGEC2(I,H) performs one step of orthonormal wavelet reconstruction on the columns of I using low-pass orthonormal (synthesis) filter H and periodic extension at the edges. The input matrix must be in the form [lowpass; highpass].

See also

PMERGE2 in the GDR Wavelet Toolbox

Author

Olivier Rioul, March 1994

psplit2

Purpose

Periodic separable wavelet split

Synopsis

I=psplit2(I,g)

Description

PSPLIT2(I,H) performs one step of orthonormal wavelet decomposition on the columns and lines of I, using low-pass orthonormal (synthesis) filter H and periodic extension at the edges. The resulting matrix is in the form [low , vert ; horiz , diag] where:
subimage "low" = horizontal and vertical low-pass component
subimage "vert" = horizontal high-pass and vertical low-pass component
subimage "horiz" = horizontal low-pass and vertical high-pass component
subimage "diag" = horizontal and vertical high-pass component

See also

PSPLITC2, PDWT2 in the GDR Wavelet Toolbox

Author

Olivier Rioul, March 1994

psplitc2

Purpose

Periodic wavelet split column by column

Synopsis

I=psplitc2(I,g)

Description

psplitc2(I,H) performs one step of orthonormal wavelet decomposition on the columns of I using low-pass orthonormal (synthesis) filter H and periodic extension at the edges. The result matrix is in the form [lowpass; highpass].

See also

PSPLIT2 in the GDR Wavelet Toolbox

Author

Olivier Rioul, March 1994

rdoptim

Purpose

Rate/distortion optimisation

Synopsis

[bpp,psnr,ar]=rdoptim(dbpp1,dbpp2)

Description

After initialization by RDOPTIM1, which specifies the image and wavelet filter, [bpp,psnr,bpparray]=rdoptim(dbpp) performs rate/distortion optimization for desired bit rate = dbpp (in bits/pixel) and gives bpp, the atcual bit rate obtained, psnr, an estimated value of the Peak SNR at reconstruction, and bpparray, the optimal array of bits per pixel for each subimage with the optimal number of decompositions.
rdoptim(dbpp1,dbpp2) plots the optimal psnr/bit rate curve for bit rates between dbpp1 and dbpp2.

[BPP,PSNR,JOPT]=rdoptim(dbpp1,dbpp2) also gives the corresponding values of psnr, bit rates and optimal numbers of decompositions.

See also

RDOPTIM1 in the GDR Wavelet Toolbox.

Author

Olivier Rioul, March 1994

rdoptim1

Purpose

Initialisation for RDOPTIM

Synopsis

rdoptim1(I,h,fname,minbpp,maxbpp,Nch)

Description

RDOPTIM(I,H,'fname',minbpp,maxbpp,Nch) does initialisation for image I, orthonormal wavelet filter H, Nch different quantizers for each subimage, with bits/pixel ranging from minbpp to maxbpp. minbpp and maxbpp are arrays indexed by (j=1:Jmax,k=0:3) of min and max bpps for subimage(j,k). The bit rate criterion is given by 'fname': If it is 'bpp', the bit rate is that allocated in the quantizers. Otherwise it should be the name of a MATLAB function giving bitrates (see ENTROPY, HUFFMANN).

See also

ENTROPY, HUFFMANN, RDOPTIM in the GDR Wavelet Toolbox.

Author

Olivier Rioul, March 1994

References

[1] Olivier Rioul, Ondelettes regulieres: Application a la compression d'images fixes, PhD Thesis, Telecom Paris, March 1993.

rdoptim2

Purpose

Inner calculations used by RDOPTIM

Synopsis

[r,d,JJopt,indd]=rdoptim2(R,D,s)

Description

rdoptim2 performs the inner calculations used by RDOPTIM.

See also

RDOPTIM in the GDR Wavelet Toolbox.

Author

Olivier Rioul, March 1994

sub

Purpose

Select sub-image

Synopsis

A=sub(S,j,k)

Description

sub(W,j,k) or sub(W,jk) returns sub-image of wavelet matrix W (as returned by PDWT2) at level j and orientation k, where:

k=0: low-pass component if j is the maximum number of levels

k=1: vertical component, k=2: horizontal component, k=3: diagonal component

sub(size(W),j,k) or sub(size(W),jk) returns index matrix A such that W(A) is the sub-image of wavelet matrix W at level j and orientation k.

w(sub(size(W),jk)) is equivalent to sub(W,jk) but the former can be used for indexing w at the lhs of an expression.

See also

PDWT2 in the GDR Wavelet Toolbox

Author

Olivier Rioul, March 1994

wbitrate

Purpose

Total bitrate of wavelet matrix

Synopsis

[s, t]=wbitrate(fname,W,J)

Description

wbitrate('fname',W,j) computes the total bitrate necessary to encode quantized wavelet matrix W on j levels. The bitrate (in bits per pixel) is computed for each subimage w using fname(w) (see ENTROPY and HUFFMANN). It returns the array of bitrates as a second argument: a matrix indexed by (j=1:J,k=0:3) which gives the bitrate for subimage (j,k) (see SUB)

See also

ENTROPY, HUFFMANN, SUB in the GDR Wavelet Toolbox

Author

Olivier Rioul, March 1994

Purpose

Quantization of wavelet coefficients

Synopsis

[W,c]=wq(fname,W,n)

Description

[Wq,c]=wq('fname',W,n) quantizes subimages (j,k) of wavelet matrix W on n(j,k) bits per pixel using quantizer 'fname' (see SQ) and returns scaling array c(j,k) as second argument (see SQ).

See also

SQ in the GDR Wavelet Toolbox.

Author

Olivier Rioul, March 1994

wvisu

Purpose

Displays wavelet matrix on the screen

Synopsis

wvisu(W,J,zoom)

Description

WVISU(W,J) or WVISU(W,J,zoom) does VISUERR by re-scaling each subimage of wavelet matrix W for better visibility. If the zoom factor is negative, wavelet coefficients are displayed in reverse video (but not the low-pass component).

See also

VISU, VISUERR in the GDR Wavelet Toolbox

Author

Olivier Rioul, March 1994

Image Quantization

Contents

isq

Purpose

Inverse uniform scalar quantization

Synopsis

I=isq(I,c)

Description

isq(I,c) rescales the pixels values in I after quantization, using:
c=a+i*b as given by SQ.
After inverse scalar quantization, any zero value will be mapped to zero.

See also

SQ in the GDR Wavelet Toolbox

Author

Olivier Rioul, March 1994

Purpose

uniform scalar quantization

Synopsis

[I,c]=sq(I,n)

Description

[Iq,c]=SQ(I,n) quantifies I on n bits/pixel. The output values in Iq lie between 0 and round(2^n)-1. Scalar c=a+i*b gives constants a and b such that Iq=round(a*I+b). After inverse scalar quantization, any zero value will be mapped to zero.

See also

ISQ in the GDR Wavelet Toolbox

Author

Olivier Rioul, March 1994