

# Package ‘imager’

May 10, 2023

**Type** Package

**Title** Image Processing Library Based on 'CImg'

**Version** 0.45.2

**Description** Fast image processing for images in up to 4 dimensions (two spatial dimensions, one time/depth dimension, one colour dimension). Provides most traditional image processing tools (filtering, morphology, transformations, etc.) as well as various functions for easily analysing image data using R. The package wraps 'CImg', <<http://cimg.eu>>, a simple, modern C++ library for image processing.

**License** LGPL-3

**Imports** Rcpp (>= 0.11.5),methods,stringr,png,jpeg,readbitmap,grDevices,purrr,downloader,iGraph

**Depends** R (>= 2.10.0),magrittr

**URL** <https://asgr.github.io/imager/>, <https://github.com/asgr/imager/>

**BugReports** <https://github.com/asgr/imager/issues>

**SystemRequirements** fftw3,libtiff,X11

**LinkingTo** Rcpp

**LazyData** true

**RoxygenNote** 7.2.3

**Suggests** knitr, rmarkdown,ggplot2,dplyr,scales, testthat,raster,spatstat.geom,magick,Cairo

**VignetteBuilder** knitr

**Encoding** UTF-8

**NeedsCompilation** yes

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**Date/Publication** 2023-05-10 07:40:12 UTC

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add.colour	<i>Add colour channels to a grayscale image or pixel set</i>
------------	--

---

### Description

Add colour channels to a grayscale image or pixel set

### Usage

```
add.colour(im, simple = TRUE)
```

```
add.color(im, simple = TRUE)
```

### Arguments

im	a grayscale image
simple	if TRUE just stack three copies of the grayscale image, if FALSE treat the image as the L channel in an HSL representation. Default TRUE. For pixel sets this option makes no sense and is ignored.

### Value

an image of class cimg

### Functions

- add.color(): Alias for add.colour

### Author(s)

Simon Barthelme

**Examples**

```
grayscale(boats) #No more colour channels
add.colour(grayscale(boats)) #Image has depth = 3 (but contains only grays)
```

---

as.cimg

---

*Convert to cimg object*


---

**Description**

Imager implements various converters that turn your data into cimg objects. If you convert from a vector (which only has a length, and no dimension), either specify dimensions explicitly or some guesswork will be involved. See examples for clarifications.

**Usage**

```
as.cimg(obj, ...)
```

```
## S3 method for class 'numeric'
as.cimg(obj, ...)
```

```
## S3 method for class 'logical'
as.cimg(obj, ...)
```

```
## S3 method for class 'double'
as.cimg(obj, ...)
```

```
## S3 method for class 'cimg'
as.cimg(obj, ...)
```

```
## S3 method for class 'vector'
as.cimg(obj, x = NA, y = NA, z = NA, cc = NA, dim = NULL, ...)
```

```
## S3 method for class 'matrix'
as.cimg(obj, ...)
```

**Arguments**

obj	an object
...	optional arguments
x	width
y	height
z	depth
cc	spectrum
dim	a vector of dimensions (optional, use instead of xyzcc)

**Methods (by class)**

- `as.cimg(numeric)`: convert numeric
- `as.cimg(logical)`: convert logical
- `as.cimg(double)`: convert double
- `as.cimg(cimg)`: return object
- `as.cimg(vector)`: convert vector
- `as.cimg(matrix)`: Convert to matrix

**Author(s)**

Simon Barthelme

**See Also**

`as.cimg.array`, `as.cimg.function`, `as.cimg.data.frame`

**Examples**

```
as.cimg(1:100,x=10,y=10) #10x10, grayscale image
as.cimg(rep(1:100,3),x=10,y=10,cc=3) #10x10 RGB
as.cimg(1:100,dim=c(10,10,1,1))
as.cimg(1:100) #Guesses dimensions, warning is issued
as.cimg(rep(1:100,3)) #Guesses dimensions, warning is issued
```

---

`as.cimg.array`

*Turn an numeric array into a cimg object*

---

**Description**

If the array has two dimensions, we assume it's a grayscale image. If it has three dimensions we assume it's a video, unless the third dimension has a depth of 3, in which case we assume it's a colour image,

**Usage**

```
## S3 method for class 'array'
as.cimg(obj, ...)
```

**Arguments**

<code>obj</code>	an array
<code>...</code>	ignored

**Examples**

```
as.cimg(array(1:9,c(3,3)))
as.cimg(array(1,c(10,10,3))) #Guesses colour image
as.cimg(array(1:9,c(10,10,4))) #Guesses video
```

---

```
as.cimg.data.frame      Create an image from a data.frame
```

---

**Description**

This function is meant to be just like `as.cimg.data.frame`, but in reverse. Each line in the data frame must correspond to a pixel. For example, the data frame can be of the form `(x,y,value)` or `(x,y,z,value)`, or `(x,y,z,cc,value)`. The coordinates must be valid image coordinates (i.e., positive integers).

**Usage**

```
## S3 method for class 'data.frame'
as.cimg(obj, v.name = "value", dims, ...)
```

**Arguments**

<code>obj</code>	a data.frame
<code>v.name</code>	name of the variable to extract pixel values from (default "value")
<code>dims</code>	a vector of length 4 corresponding to image dimensions. If missing, a guess will be made.
<code>...</code>	ignored

**Value**

an object of class `cimg`

**Author(s)**

Simon Barthelme

**Examples**

```
#Create a data.frame with columns x,y and value
df <- expand.grid(x=1:10,y=1:10) %>% dplyr::mutate(value=x*y)
#Convert to cimg object (2D, grayscale image of size 10*10
as.cimg(df,dims=c(10,10,1,1)) %>% plot
```

---

as.cimg.function      *Create an image by sampling a function*

---

### Description

Similar to as.im.function from the spatstat package, but simpler. Creates a grid of pixel coordinates  $x=1:\text{width}, y=1:\text{height}$  and (optional)  $z=1:\text{depth}$ , and evaluates the input function at these values.

### Usage

```
## S3 method for class ``function``
as.cimg(
  obj,
  width,
  height,
  depth = 1,
  spectrum = 1,
  standardise = FALSE,
  dim = NULL,
  ...
)
```

### Arguments

obj	a function with arguments (x,y), or (x,y,cc), or (x,y,z), etc. Must be vectorised; see examples.
width	width of the image (in pixels)
height	height of the image (in pixels)
depth	depth of the image (in pixels). Default 1.
spectrum	number of colour channels. Defaut 1.
standardise	coordinates are scaled and centered (see doc for pixel.grid)
dim	a vector of image dimensions (can be used instead of width, height, etc.)
...	ignored

### Value

an object of class cimg

### Author(s)

Simon Barthelme

**Examples**

```

im = as.cimg(function(x,y) cos(sin(x*y/100)),100,100)
plot(im)
#The following is just a rectangle at the center of the image
im = as.cimg(function(x,y) (abs(x) < .1)*(abs(y) < .1) ,100,100,standardise=TRUE)
plot(im)
#Since coordinates are standardised the rectangle scales with the size of the image
im = as.cimg(function(x,y) (abs(x) < .1)*(abs(y) < .1) ,200,200,standardise=TRUE)
plot(im)
#A Gaussian mask around the center
im = as.cimg(function(x,y) dnorm(x,sd=.1)*dnorm(y,sd=.3) ,dim=dim(boats),standardise=TRUE)
im = im/max(im)

plot(im*boats)
#A Gaussian mask for just the red channel
fun = function(x,y,cc) ifelse(cc==1, dnorm(x,sd=.1)*dnorm(y,sd=.3),0)
im = as.cimg(fun,dim=dim(boats),standardise=TRUE)
plot(im*boats)

```

---

as.cimg.im

---

*Convert an image in spatstat format to an image in cimg format*


---

**Description**

Convert an image in spatstat format to an image in cimg format

**Usage**

```

## S3 method for class 'im'
as.cimg(obj, ...)

```

**Arguments**

obj	a spatstat image
...	optional arguments

**Value**

a cimg image

**Author(s)**

Simon Barthelme

---

as.cimg.raster	<i>Convert a raster object to a cimg object</i>
----------------	---

---

**Description**

R's native object for representing images is a "raster". This function converts raster objects to cimg objects.

**Usage**

```
## S3 method for class 'raster'  
as.cimg(obj, ...)
```

**Arguments**

obj	a raster object
...	ignored

**Value**

a cimg object

**Author(s)**

Simon Barthelme

**Examples**

```
rst <- as.raster(matrix((1:4)/4,2,2))  
as.cimg(rst) %>% plot(int=FALSE)  
all.equal(rst,as.raster(as.cimg(rst)))
```

---

as.data.frame.cimg	<i>Convert a pixel image to a data.frame</i>
--------------------	--

---

**Description**

This function combines the output of pixel.grid with the actual values (stored in \$value)

**Usage**

```
## S3 method for class 'cimg'  
as.data.frame(x, ..., wide = c(FALSE, "c", "d"))
```

**Arguments**

x	an image of class cimg
...	arguments passed to pixel.grid
wide	if "c" or "d" return a data.frame that is wide along colour or depth (for example with rgb values along columns). The default is FALSE, with each pixel forming a separate entry.

**Value**

a data.frame

**Author(s)**

Simon Barthelme

**Examples**

```
#First five pixels
as.data.frame(boats) %>% head(5)
#Wide format along colour axis
as.data.frame(boats,wide="c") %>% head(5)
```

---

as.data.frame.imlist *Convert image list to data.frame*

---

**Description**

Convert image list to data.frame

**Usage**

```
## S3 method for class 'imlist'
as.data.frame(x, ..., index = "im")
```

**Arguments**

x	an image list (an imlist object)
...	Passed on to as.data.frame.cimg
index	Name of the column containing the index (or name) of the image in the list. Default: "im"

**Examples**

```
#Transform the image gradient into a data.frame
gr <- imgradient(boats,"xy") %>% setNames(c("dx","dy")) %>% as.data.frame
str(gr)
```

---

as.data.frame.pixset    *Methods to convert pixsets to various objects*

---

### Description

Methods to convert pixsets to various objects

### Usage

```
## S3 method for class 'pixset'  
as.data.frame(x, ..., drop = FALSE)
```

### Arguments

x	pixset to convert
...	ignored
drop	drop flat dimensions

### See Also

where

### Examples

```
px <- boats > 250  
#Convert to array of logicals  
as.logical(px) %>% dim  
#Convert to data.frame: gives all pixel locations in the set  
as.data.frame(px) %>% head  
#Drop flat dimensions  
as.data.frame(px,drop=TRUE) %>% head
```

---

as.igraph.cimg    *Form a graph from an image*

---

### Description

In this graph representation, every pixel is a vertex connected to its neighbours. The image values along edges are stored as graph attributes (see examples).

### Usage

```
## S3 method for class 'cimg'  
as.igraph(x, mask = px.all(channel(im, 1)), ...)
```

**Arguments**

x	an image (must be 2D, 3D not implemented yet)
mask	optional: a pixset. if provided, pixels are only connected if they are both in the pixset.
...	ignored

**Value**

a graph (igraph format) with attributes value.from, value.to and dist

**Author(s)**

Simon Barthelme

**See Also**

as.igraph.pixset

**Examples**

```

library(igraph)
im <- imfill(5,5)
G <- as.igraph(im)
plot(G)
#Shortest-path distance from pixel 1 to all other pixels
d <- igraph::distances(G,1) %>% as.vector
as.cimg(d,dim=gsdim(im)) %>% plot(interpolate=FALSE)
#Notice that moving along the diagonal has the same cost
#as moving along the cardinal directions, whereas the Euclidean distance
#is actually sqrt(2) and not 1.
#Modify weight attribute, to change the way distance is computed
igraph::E(G)$weight <- G$dist
d2 <- igraph::distances(G,1) %>% as.vector
as.cimg(d2,dim=gsdim(im)) %>% plot(interpolate=FALSE)
#More interesting example
im <- grayscale(boats)
G <- as.igraph(im)
#value.from holds the value of the source pixel, value.to the sink's
#set w_ij = (|v_i - v_j|)/d_ij
igraph::E(G)$weight <- (abs(G$value.from - G$value.to))/G$dist
igraph::distances(G,5000) %>% as.vector %>%
  as.cimg(dim=gsdim(im)) %>% plot

```

---

as.igraph.pixset      *Form an adjacency graph from a pixset*

---

### Description

Return a graph where nodes are pixels, and two nodes are connected if and only if both nodes are in the pixset, and the pixels are adjacent. Optionnally, add weights corresponding to distance (either 1 or  $\sqrt{2}$ ), depending on the orientation of the edge). The graph is represented as an igraph "graph" object

### Usage

```
## S3 method for class 'pixset'
as.igraph(x, weighted = TRUE, ...)
```

### Arguments

x	a pixset
weighted	add weight for distance (default TRUE)
...	ignored

### Value

an igraph "graph" object

### See Also

as.igraph.cimg

### Examples

```
library(igraph)
#Simple 3x3 lattice
px <- px.all(imfill(3,3))
as.igraph(px) %>% plot
#Disconnect central pixel
px[5] <- FALSE
as.igraph(px) %>% plot
#Form graph from thresholded image
im <- load.example("coins")
px <- threshold(im) %>% fill(5)
G <- as.igraph(px)
#Label connected components
v <- (igraph::clusters(G)$membership)
as.cimg(v,dim=dim(px)) %>% plot
#Find a path across the image that avoids all
#the coins
```

```
G <- as.igraph(!px)
start <- index.coord(im,data.frame(x=1,y=100))
end <- index.coord(im,data.frame(x=384,y=300))
sp <- igraph::shortest_paths(G,start,end,output="vpath")
path <- sp$vpath[[1]] %>% as.integer %>% coord.index(im,..)
```

---

as.imlist.list                      *Convert various objects to image lists*

---

### Description

Convert various objects to image lists

### Usage

```
## S3 method for class 'list'
as.imlist(obj, ...)

as.imlist(obj, ...)

## S3 method for class 'imlist'
as.imlist(obj, ...)

## S3 method for class 'cimg'
as.imlist(obj, ...)
```

### Arguments

obj	an image list
...	ignored

### Value

a list

### Methods (by class)

- as.imlist(list): convert from list
- as.imlist(imlist): Convert from imlist (identity)
- as.imlist(cimg): Convert from image

### Examples

```
list(a=boats,b=boats*2) %>% as.imlist
```

---

`as.pixset`*Methods to convert various objects to pixsets*

---

## Description

Methods to convert various objects to pixsets

## Usage

```
as.pixset(x, ...)  
  
## S3 method for class 'cimg'  
as.pixset(x, ...)  
  
## S3 method for class 'pixset'  
as.cimg(obj, ...)
```

## Arguments

<code>x</code>	object to convert to pixset
<code>...</code>	ignored
<code>obj</code>	pixset to convert

## Methods (by class)

- `as.pixset(cimg)`: convert cimg to pixset

## Functions

- `as.cimg(pixset)`: convert pixset to cimg

## Examples

```
#When converting an image to a pixset, the default is to include all pixels with non-zero value  
as.pixset(boats)  
#The above is equivalent to:  
boats!=0
```

---

as.raster.cimg

---

*Convert a cimg object to a raster object for plotting*


---

### Description

raster objects are used by R's base graphics for plotting. R wants hexadecimal RGB values for plotting, e.g. `gray(0)` yields `#000000`, meaning black. If you want to control precisely how numerical values are turned into colours for plotting, you need to specify a colour scale using the `colourscale` argument (see examples). Otherwise the default is "gray" for grayscale images, "rgb" for colour. These expect values in `[0..1]`, so the default is to rescale the data to `[0..1]`. If you wish to over-ride that behaviour, set `rescale=FALSE`.

### Usage

```
## S3 method for class 'cimg'
as.raster(
  x,
  frames,
  rescale = TRUE,
  colourscale = NULL,
  colorscale = NULL,
  col.na = rgb(0, 0, 0, 0),
  ...
)
```

### Arguments

<code>x</code>	an image (of class <code>cimg</code> )
<code>frames</code>	which frames to extract (in case <code>depth &gt; 1</code> )
<code>rescale</code>	rescale so that pixel values are in <code>[0,1]</code> ? (subtract min and divide by range). default <code>TRUE</code>
<code>colourscale</code>	a function that returns RGB values in hexadecimal
<code>colorscale</code>	same as above in American spelling
<code>col.na</code>	which colour to use for NA values, as R rgb code. The default is <code>"rgb(0,0,0,0)"</code> , which corresponds to a fully transparent colour.
<code>...</code>	ignored

### Value

a raster object

### Author(s)

Simon Barthelme

**See Also**

plot.cimg, rasterImage

**Examples**

```
#A raster is a simple array of RGB values
as.raster(boats) %>% str
#By default as.raster rescales input values, so that:
all.equal(as.raster(boats),as.raster(boats/2)) #TRUE
#Setting rescale to FALSE changes that
as.raster(boats,rescale=FALSE) %>% plot
as.raster(boats/2,rescale=FALSE) %>% plot
#For grayscale images, a colourmap should take a single value and
#return an RGB code
#Example: mapping grayscale value to saturation
cscale <- function(v) hsv(.5,v,1)
grayscale(boats) %>% as.raster(colourscale=cscale) %>% plot
```

---

at	<i>Return or set pixel value at coordinates</i>
----	---

---

**Description**

Return or set pixel value at coordinates

**Usage**

```
at(im, x, y, z = 1, cc = 1)

at(im, x, y, z = 1, cc = 1) <- value

color.at(im, x, y, z = 1)

color.at(im, x, y, z = 1) <- value
```

**Arguments**

im	an image (cimg object)
x	x coordinate (vector)
y	y coordinate (vector)
z	z coordinate (vector, default 1)
cc	colour coordinate (vector, default 1)
value	replacement

**Value**

pixel values

**Functions**

- `at(im, x, y, z = 1, cc = 1) <- value`: set value of pixel at a location
- `color.at()`: return value of all colour channels at a location
- `color.at(im, x, y, z = 1) <- value`: set value of all colour channels at a location

**Author(s)**

Simon Barthelme

**Examples**

```
im <- as.cimg(function(x,y) x+y,50,50)
at(im,10,1)
at(im,10:12,1)
at(im,10:12,1:3)
at(im,1,2) <- 10
at(im,1,2)

color.at(boats,x=10,y=10)

im <- boats
color.at(im,x=10,y=10) <- c(255,0,0)
#There should now be a red dot
imshow(im, x %inr% c(1,100), y %inr% c(1,100)) %>% plot
```

---

autocrop

*Autocrop image region*

---

**Description**

Autocrop image region

**Usage**

```
autocrop(im, color = color.at(im, 1, 1), axes = "zyx")
```

**Arguments**

<code>im</code>	an image
<code>color</code>	Colour used for the crop. If missing, the colour is taken from the top-left pixel. Can also be a colour name (e.g. "red", or "black")
<code>axes</code>	Axes used for the crop.

## Examples

```
#Add pointless padding
padded <- pad(boats,30,"xy")
plot(padded)
#Remove padding
autocrop(padded) %>% plot
#You can specify the colour if needs be
autocrop(padded,"black") %>% plot
#autocrop has a zero-tolerance policy: if a pixel value is slightly different from the one you gave
#the pixel won't get cropped. A fix is to do a bucket fill first
padded <- isoblur(padded,10)
autocrop(padded) %>% plot
padded2 <- bucketfill(padded,1,1,col=c(0,0,0),sigma=.1)
autocrop(padded2) %>% plot
```

---

 bbox

---

*Compute the bounding box of a pixset*


---

## Description

This function returns the bounding box of a pixset as another pixset. If the image has more than one frame, a bounding cube is returned. If the image has several colour channels, the bounding box is computed separately in each channel. `crop.bbox` crops an image using the bounding box of a pixset.

## Usage

```
bbox(px)
```

```
crop.bbox(im, px)
```

## Arguments

px	a pixset
im	an image

## Value

a pixset object

## Functions

- `crop.bbox()`: crop image using the bounding box of pixset px

## Author(s)

Simon Barthelme

**Examples**

```

im <- grayscale(boats)
px <- im > .85
plot(im)
highlight(bbox(px))
highlight(px,col="green")
crop.bbox(im,px) %>% plot

```

---

blur_anisotropic	<i>Blur image anisotropically, in an edge-preserving way.</i>
------------------	---

---

**Description**

Standard blurring removes noise from images, but tends to smooth away edges in the process. This anisotropic filter preserves edges better.

**Usage**

```

blur_anisotropic(
  im,
  amplitude,
  sharpness = 0.7,
  anisotropy = 0.6,
  alpha = 0.6,
  sigma = 1.1,
  dl = 0.8,
  da = 30,
  gauss_prec = 2,
  interpolation_type = 0L,
  fast_approx = TRUE
)

```

**Arguments**

im	an image
amplitude	Amplitude of the smoothing.
sharpness	Sharpness.
anisotropy	Anisotropy.
alpha	Standard deviation of the gradient blur.
sigma	Standard deviation of the structure tensor blur.
dl	Spatial discretization.
da	Angular discretization.
gauss_prec	Precision of the diffusion process.
interpolation_type	Interpolation scheme. Can be 0=nearest-neighbor   1=linear   2=Runge-Kutta
fast_approx	If true, use fast approximation (default TRUE)

**Examples**

```
im <- load.image(system.file('extdata/Leonardo_Birds.jpg',package='imager'))
im.noisy <- (im + 80*rnorm(prod(dim(im))))
blur_anisotropic(im.noisy,ampl=1e4,sharp=1) %>% plot
```

---

boats

*Photograph of sailing boats from Kodak set*

---

**Description**

This photograph was downloaded from <http://r0k.us/graphics/kodak/kodim09.html>. Its size was reduced by half to speed up loading and save space.

**Usage**

boats

**Format**

an image of class cimg

**Source**

<http://r0k.us/graphics/kodak/kodim09.html>

---

boundary

*Find the boundary of a shape in a pixel set*

---

**Description**

Find the boundary of a shape in a pixel set

**Usage**

```
boundary(px, depth = 1, high_connexity = FALSE)
```

**Arguments**

px                    pixel set  
depth                boundary depth (default 1)  
high\_connexity    if FALSE, use 4-point neighbourhood. If TRUE, use 8-point. (default FALSE)

## Examples

```
px.diamond(10,30,30) %>% boundary %>% plot
px.square(10,30,30) %>% boundary %>% plot
px.square(10,30,30) %>% boundary(depth=3) %>% plot
px <- (px.square(10,30,30) | px.circle(12,30,30))
boundary(px,high=TRUE) %>% plot(int=TRUE,main="8-point neighbourhood")
boundary(px,high=TRUE) %>% plot(int=FALSE,main="4-point neighbourhood")
```

---

boxblur

*Blur image with a box filter (square window)*

---

## Description

Blur image with a box filter (square window)

## Usage

```
boxblur(im, boxsize, neumann = TRUE)
```

## Arguments

im	an image
boxsize	Size of the box window (can be subpixel).
neumann	If true, use Neumann boundary conditions, Dirichlet otherwise (default true, Neumann)

## See Also

deriche(), vanvliet().

## Examples

```
boxblur(boats,5) %>% plot(main="Dirichlet boundary")
boxblur(boats,5,TRUE) %>% plot(main="Neumann boundary")
```

---

boxblur_xy	<i>Blur image with a box filter.</i>
------------	--------------------------------------

---

**Description**

This is a recursive algorithm, not depending on the values of the box kernel size.

**Usage**

```
boxblur_xy(im, sx, sy, neumann = TRUE)
```

**Arguments**

im	an image
sx	Size of the box window, along the X-axis.
sy	Size of the box window, along the Y-axis.
neumann	If true, use Neumann boundary conditions, Dirichlet otherwise (default true, Neumann)

**See Also**

blur().

**Examples**

```
boxblur_xy(boats,20,5) %>% plot(main="Anisotropic blur")
```

---

bucketfill	<i>Bucket fill</i>
------------	--------------------

---

**Description**

Bucket fill

**Usage**

```
bucketfill(  
  im,  
  x,  
  y,  
  z = 1,  
  color,  
  opacity = 1,  
  sigma = 0,  
  high_connexity = FALSE  
)
```

**Arguments**

im	an image
x	X-coordinate of the starting point of the region to fill.
y	Y-coordinate of the starting point of the region to fill.
z	Z-coordinate of the starting point of the region to fill.
color	a vector of values (of length spectrum(im)), or a colour name (e.g. "red"). If missing, use the colour at location (x,y,z).
opacity	opacity. If the opacity is below 1, paint with transparency.
sigma	Tolerance for neighborhood values: spread to neighbours if difference is less than sigma (for grayscale). If there are several channels, the sum of squared differences is used: if it below sigma <sup>2</sup> , the colour spreads.
high_connexity	Use 8-connexity (only for 2d images, default FALSE).

**See Also**

px.flood

**Examples**

```
#Change the colour of a sail
boats.new <- bucketfill(boats,x=169,y=179,color="pink",sigma=.2)
layout(t(1:2))
plot(boats,main="Original")
plot(boats.new,main="New sails")

#More spreading, lower opacity, colour specified as vector
ugly <- bucketfill(boats,x=169,y=179,color=c(0,1,0),sigma=.6,opacity=.5)
plot(ugly)
```

---

cannyEdges

*Canny edge detector*

---

**Description**

If the threshold parameters are missing, they are determined automatically using a k-means heuristic. Use the alpha parameter to adjust the automatic thresholds up or down. The thresholds are returned as attributes. The edge detection is based on a smoothed image gradient with a degree of smoothing set by the sigma parameter.

**Usage**

```
cannyEdges(im, t1, t2, alpha = 1, sigma = 2)
```

**Arguments**

im	input image
t1	threshold for weak edges (if missing, both thresholds are determined automatically)
t2	threshold for strong edges
alpha	threshold adjustment factor (default 1)
sigma	smoothing

**Author(s)**

Simon Barthelme

**Examples**

```
cannyEdges(boats) %>% plot
#Make thresholds less strict
cannyEdges(boats,alpha=.4) %>% plot
#Make thresholds more strict
cannyEdges(boats,alpha=1.4) %>% plot
```

---

capture.plot

*Capture the current R plot device as a cimg image*

---

**Description**

Capture the current R plot device as a cimg image

**Usage**

```
capture.plot()
```

**Value**

a cimg image corresponding to the contents of the current plotting window

**Author(s)**

Simon Barthelme

**Examples**

```
##interactive only:
##plot(1:10)
###Make a plot of the plot
##capture.plot() %>% plot
```

---

<code>center.stencil</code>	<i>Center stencil at a location</i>
-----------------------------	-------------------------------------

---

**Description**

Center stencil at a location

**Usage**

```
center.stencil(stencil, ...)
```

**Arguments**

<code>stencil</code>	a stencil (data.frame with coordinates dx,dy,dz,dc)
<code>...</code>	centering locations (e.g. x=4,y=2)

**Examples**

```
stencil <- data.frame(dx=seq(-2,2,1),dy=seq(-2,2,1))
center.stencil(stencil,x=10,y=20)
```

---

<code>channels</code>	<i>Split a colour image into a list of separate channels</i>
-----------------------	--

---

**Description**

Split a colour image into a list of separate channels

**Usage**

```
channels(im, index, drop = FALSE)
```

**Arguments**

<code>im</code>	an image
<code>index</code>	which channels to extract (default all)
<code>drop</code>	if TRUE drop extra dimensions, returning normal arrays and not cimg objects

**Value**

a list of channels

**See Also**

frames

## Examples

```
channels(boats)
channels(boats,1:2)
channels(boats,1:2,drop=TRUE) %>% str #A list of 2D arrays
```

---

ci *Concatenation for image lists*

---

## Description

Allows you to concatenate image lists together, or images with image lists. Doesn't quite work like R's "c" primitive: image lists are always *flat*, not nested, meaning each element of an image list is an image.

## Usage

```
ci(...)
```

## Arguments

```
...          objects to concatenate
```

## Value

an image list

## Author(s)

Simon Barthelme

## Examples

```
l1 <- imlist(boats,grayscale(boats))
l2 <- imgradient(boats,"xy")
ci(l1,l2) #List + list
ci(l1,imfill(3,3)) #List + image
ci(imfill(3,3),l1,l2) #Three elements, etc.
```

cimg

*Create a cimg object*

---

**Description**

cimg is a class for storing image or video/hyperspectral data. It is designed to provide easy interaction with the CImg library, but in order to use it you need to be aware of how CImg wants its image data stored. Images have up to 4 dimensions, labelled x,y,z,c. x and y are the usual spatial dimensions, z is a depth dimension (which would correspond to time in a movie), and c is a colour dimension. Images are stored linearly in that order, starting from the top-left pixel and going along \*rows\* (scanline order). A colour image is just three R,G,B channels in succession. A sequence of N images is encoded as R1,R2,...,RN,G1,...,GN,B1,...,BN where R\_i is the red channel of frame i. The number of pixels along the x,y,z, and c axes is called (in that order), width, height, depth and spectrum. NB: Logical and integer values are automatically converted to type double. NAs are not supported by CImg, so you should manage them on the R end of things.

**Usage**

```
cimg(X)
```

**Arguments**

X                    a four-dimensional numeric array

**Value**

an object of class cimg

**Author(s)**

Simon Barthelme

**Examples**

```
cimg(array(1,c(10,10,5,3)))
```

---

cimg.dimensions*Image dimensions*

---

**Description**

Image dimensions

**Usage**`width(im)``height(im)``spectrum(im)``depth(im)``nPix(im)`**Arguments**`im`            an image**Functions**

- `width()`: Width of the image (in pixels)
- `height()`: Height of the image (in pixels)
- `spectrum()`: Number of colour channels
- `depth()`: Depth of the image/number of frames in a video
- `nPix()`: Total number of pixels (`prod(dim(im))`)

---

`cimg.extract`*Various shortcuts for extracting colour channels, frames, etc*

---

**Description**

Various shortcuts for extracting colour channels, frames, etc

Extract one frame out of a 4D image/video

**Usage**`frame(im, index)``imcol(im, x)``imrow(im, y)``channel(im, ind)``R(im)``G(im)``B(im)`

**Arguments**

im	an image
index	frame index
x	x coordinate of the row
y	y coordinate of the row
ind	channel index

**Functions**

- `frame()`: Extract frame
- `imcol()`: Extract a particular column from an image
- `imrow()`: Extract a particular row from an image
- `channel()`: Extract an image channel
- `R()`: Extract red channel
- `G()`: Extract green channel
- `B()`: Extract blue channel

**Author(s)**

Simon Barthelme

**Examples**

```
#Extract the red channel from the boats image, then the first row, plot
rw <- R(boats) %>% imrow(10)
plot(rw,type="l",xlab="x",ylab="Pixel value")
#Note that R(boats) returns an image
R(boats)
#while imrow returns a vector or a list
R(boats) %>% imrow(1) %>% str
imrow(boats,1) %>% str
```

---

cimg.openmp

*Control CImg's parallelisation*

---

**Description**

On supported architectures CImg can parallelise many operations using OpenMP (e.g. [imager.combine](#)). Use this function to turn parallelisation on or off.

**Usage**

```
cimg.use.openmp(mode = "adaptive", nthreads = 1, verbose = FALSE)

cimg.limit.openmp()
```

**Arguments**

mode	Either "adaptive", "always" or "none". The default is adaptive (parallelisation for large images only).
nthreads	The number of OpenMP threads that imager should use. The default is 1. Set to 0 to get no more than 2, based on OpenMP environment variables.
verbose	Whether to output information about the threads being set.

**Details**

You need to be careful that 'nthreads' is not higher than the value in the system environment variable OMP\_THREAD\_LIMIT (this can be checked with `Sys.getenv('OMP_THREAD_LIMIT')`). The OMP\_THREAD\_LIMIT thread limit usually needs to be correctly set before launching R, so using `Sys.setenv` once a session has started is not certain to work.

**Value**

NULL (function is used for side effects)

**Functions**

- `cimg.limit.openmp()`: Limit OpenMP thread count to no more than 2, based on OpenMP environment variables.

**Author(s)**

Simon Barthelme

**Examples**

```
cimg.use.openmp("never") #turn off parallelisation
```

---

cimg2im

*Convert cim to spatstat im object*

---

**Description**

The spatstat library uses a different format for images, which have class "im". This utility converts a cim object to an im object. spatstat im objects are limited to 2D grayscale images, so if the image has depth or spectrum > 1 a list is returned for the separate frames or channels (or both, in which case a list of lists is returned, with frames at the higher level and channels at the lower one).

**Usage**

```
cimg2im(img, W = NULL)
```

**Arguments**

<code>img</code>	an image of class <code>cimg</code>
<code>W</code>	a spatial window (see <code>spatstat</code> doc). Default <code>NULL</code>

**Value**

an object of class `im`, or a list of objects of class `im`, or a list of lists of objects of class `im`

**Author(s)**

Simon Barthelme

**See Also**

`im`, `as.im`

---

`circles`

*Add circles to plot*

---

**Description**

Base R has a function for plotting circles called "symbols". Unfortunately, the size of the circles is inconsistent across devices. This function plots circles whose radius is specified in user coordinates.

**Usage**

```
circles(x, y, radius, bg = NULL, fg = "white", ...)
```

**Arguments**

<code>x</code>	centers (x coordinate)
<code>y</code>	centers (y coordinate)
<code>radius</code>	radius (in user coordinates)
<code>bg</code>	background colour
<code>fg</code>	foreground colour
<code>...</code>	passed to <code>polygon</code> , e.g. <code>lwd</code>

**Value**

none, used for side effect

**Author(s)**

Simon Barthelme

**See Also**

hough\_circle

clean

*Clean up and fill in pixel sets (morphological opening and closing)***Description**

Cleaning up a pixel set here means removing small isolated elements (speckle). Filling in means removing holes. Cleaning up can be achieved by shrinking the set (removing speckle), followed by growing it back up. Filling in can be achieved by growing the set (removing holes), and shrinking it again.

**Usage**

clean(px, ...)

fill(px, ...)

**Arguments**

px            a pixset

...            parameters that define the structuring element to use, passed on to "grow" and "shrink"

**Functions**

- fill(): Fill in holes using morphological closing

**Author(s)**

Simon Barthelme

**Examples**

```
im <- load.example("birds") %>% grayscale
sub <- imsub(-im,y> 380) %>% threshold("85%")
plot(sub)
#Turn into a pixel set
px <- sub==1
layout(t(1:2))
plot(px,main="Before clean-up")
clean(px,3) %>% plot(main="After clean-up")
```

```
#Now fill in the holes
px <- clean(px,3)
plot(px,main="Before filling-in")
fill(px,28) %>% plot(main="After filling-in")
```

---

colorise

*Fill in a colour in an area given by a pixset*


---

## Description

Paint all pixels in pixset px with the same colour

## Usage

```
colorise(im, px, col, alpha = 1)
```

## Arguments

im	an image
px	either a pixset or a formula, as in imeval.
col	colour to fill in. either a vector of numeric values or a string (e.g. "red")
alpha	transparency (default 1, no transparency)

## Value

an image

## Author(s)

Simon Barthelme

## Examples

```
im <- load.example("coins")
colorise(im,Xc(im) < 50,"blue") %>% plot
#Same thing with the formula interface
colorise(im,~ x < 50,"blue") %>% plot
#Add transparency
colorise(im,~ x < 50,"blue",alpha=.5) %>% plot
#Highlight pixels with low luminance values
colorise(im,~ . < 0.3,"blue",alpha=.2) %>% plot
```

---

common_pixsets	<i>Various useful pixsets</i>
----------------	-------------------------------

---

### Description

These functions define some commonly used pixsets. `px.left` gives the left-most pixels of an image, `px.right` the right-most, etc. `px.circle` returns an (approximately) circular pixset of radius `r`, embedded in an image of width `x` and height `y`. Mathematically speaking, the set of all pixels whose L2 distance to the center equals `r` or less. `px.diamond` is similar but returns a diamond (L1 distance less than `r`) `px.square` is also similar but returns a square (Linf distance less than `r`)

### Usage

```
px.circle(r, x = 2 * r + 1, y = 2 * r + 1)
px.diamond(r, x = 2 * r + 1, y = 2 * r + 1)
px.square(r, x = 2 * r + 1, y = 2 * r + 1)
px.left(im, n = 1)
px.top(im, n = 1)
px.bottom(im, n = 1)
px.right(im, n = 1)
px.borders(im, n = 1)
px.all(im)
px.none(im)
```

### Arguments

<code>r</code>	radius (in pixels)
<code>x</code>	width (default $2*r+1$ )
<code>y</code>	height (default $2*r+1$ )
<code>im</code>	an image
<code>n</code>	number of pixels to include

### Value

a pixset

**Functions**

- `px.circle()`: A circular-shaped pixset
- `px.diamond()`: A diamond-shaped pixset
- `px.square()`: A square-shaped pixset
- `px.left()`: `n` left-most pixels (left-hand border)
- `px.top()`: `n` top-most pixels
- `px.bottom()`: `n` bottom-most pixels
- `px.right()`: `n` right-most pixels
- `px.borders()`: image borders (to depth `n`)
- `px.all()`: all pixels in image
- `px.none()`: no pixel in image

**Author(s)**

Simon Barthelme

**Examples**

```
px.circle(20,350,350) %>% plot(interp=FALSE)
px.circle(3) %>% plot(interp=FALSE)
r <- 5
layout(t(1:3))
plot(px.circle(r,20,20))
plot(px.square(r,20,20))
plot(px.diamond(r,20,20))
#These pixsets are useful as structuring elements
px <- grayscale(boats) > .8
grow(px,px.circle(5)) %>% plot
#The following functions select pixels on the left, right, bottom, top of the image
im <- imfill(10,10)
px.left(im,3) %>% plot(int=FALSE)
px.right(im,1) %>% plot(int=FALSE)
px.top(im,4) %>% plot(int=FALSE)
px.bottom(im,2) %>% plot(int=FALSE)
#All of the above
px.borders(im,1) %>% plot(int=FALSE)
```

---

contours

*Return contours of image/pixset*

---

**Description**

This is just a light interface over `contourLines`. See help for `contourLines` for details. If the image has more than one colour channel, return a list with the contour lines in each channel. Does not work on 3D images.

**Usage**

```
contours(x, nlevels, ...)
```

**Arguments**

x                    an image or pixset  
nlevels             number of contour levels. For pixsets this can only equal two.  
...                  extra parameters passed to contourLines

**Value**

a list of contours

**Author(s)**

Simon Barthelme

**See Also**

highlight

**Examples**

```
boats.gs <- grayscale(boats)
ct <- contours(boats.gs,nlevels=3)
plot(boats.gs)
#Add contour lines
purrr::walk(ct,function(v) lines(v$x,v$y,col="red"))
#Contours of a pixel set
px <- boats.gs > .8
plot(boats.gs)
ct <- contours(px)
#Highlight pixset
purrr::walk(ct,function(v) lines(v$x,v$y,col="red"))
```

---

coord.index

*Coordinates from pixel index*

---

**Description**

Compute (x,y,z,cc) coordinates from linear pixel index.

**Usage**

```
coord.index(im, index)
```

**Arguments**

im                    an image  
 index                a vector of indices

**Value**

a data.frame of coordinate values

**Author(s)**

Simon Barthelme

**See Also**

index.coord for the reverse operation

**Examples**

```
cind <- coord.index(boats,33)
#Returns (x,y,z,c) coordinates of the 33rd pixel in the array
cind
all.equal(boats[33],with(cind,at(boats,x,y,z,cc)))
all.equal(33,index.coord(boats,cind))
```

---

correlate

*Correlation/convolution of image by filter*

---

**Description**

The correlation of image im by filter flt is defined as:  $res(x, y, z) = \sum_{i,j,k} im(x+i, y+j, z+k) * flt(i, j, k)$ . The convolution of an image img by filter flt is defined to be:  $res(x, y, z) = \sum_{i,j,k} img(x-i, y-j, z-k) * flt(i, j, k)$

**Usage**

```
correlate(im, filter, dirichlet = TRUE, normalise = FALSE)
```

```
convolve(im, filter, dirichlet = TRUE, normalise = FALSE)
```

**Arguments**

im                    an image  
 filter                the correlation kernel.  
 dirichlet            boundary condition. Dirichlet if true, Neumann if false (default TRUE, Dirichlet)  
 normalise            compute a normalised correlation (ie. local cosine similarity)

**Functions**

- convolve(): convolve image with filter

**Examples**

```
#Edge filter
filter <- as.cimg(function(x,y) sign(x-5),10,10)
layout(t(1:2))
#Convolution vs. correlation
correlate(boats,filter) %>% plot(main="Correlation")
convolve(boats,filter) %>% plot(main="Convolution")
```

---

crop.borders

*Crop the outer margins of an image*

---

**Description**

This function crops pixels on each side of an image. This function is a kind of inverse (centred) padding, and is useful e.g. when you want to get only the valid part of a convolution

**Usage**

```
crop.borders(im, nx = 0, ny = 0, nz = 0, nPix)
```

**Arguments**

im	an image
nx	number of pixels to crop along horizontal axis
ny	number of pixels to crop along vertical axis
nz	number of pixels to crop along depth axis
nPix	optional: crop the same number of pixels along all dimensions

**Value**

an image

**Author(s)**

Simon Barthelme

**Examples**

```
#These two versions are equivalent
imfill(10,10) %>% crop.borders(nx=1,ny=1)
imfill(10,10) %>% crop.borders(nPix=1)

#Filter, keep valid part
correlate(boats,imfill(3,3)) %>% crop.borders(nPix=2)
```

---

 deriche

*Apply recursive Deriche filter.*


---

**Description**

The Deriche filter is a fast approximation to a Gaussian filter (order = 0), or Gaussian derivatives (order = 1 or 2).

**Usage**

```
deriche(im, sigma, order = 0L, axis = "x", neumann = FALSE)
```

**Arguments**

im	an image
sigma	Standard deviation of the filter.
order	Order of the filter. 0 for a smoothing filter, 1 for first-derivative, 2 for second.
axis	Axis along which the filter is computed ( 'x' , 'y' , 'z' or 'c' ).
neumann	If true, use Neumann boundary conditions (default false, Dirichlet)

**Examples**

```
deriche(boats,sigma=2,order=0) %>% plot("Zeroth-order Deriche along x")
deriche(boats,sigma=2,order=1) %>% plot("First-order Deriche along x")
deriche(boats,sigma=2,order=1) %>% plot("Second-order Deriche along x")
deriche(boats,sigma=2,order=1,axis="y") %>% plot("Second-order Deriche along y")
```

---

diffusion\_tensors      *Compute field of diffusion tensors for edge-preserving smoothing.*

---

### Description

Compute field of diffusion tensors for edge-preserving smoothing.

### Usage

```
diffusion_tensors(
    im,
    sharpness = 0.7,
    anisotropy = 0.6,
    alpha = 0.6,
    sigma = 1.1,
    is_sqrt = FALSE
)
```

### Arguments

im	an image
sharpness	Sharpness
anisotropy	Anisotropy
alpha	Standard deviation of the gradient blur.
sigma	Standard deviation of the structure tensor blur.
is_sqrt	Tells if the square root of the tensor field is computed instead.

---

displacement      *Estimate displacement field between two images.*

---

### Description

Estimate displacement field between two images.

### Usage

```
displacement(
    sourceIm,
    destIm,
    smoothness = 0.1,
    precision = 5,
    nb_scales = 0L,
    iteration_max = 10000L,
    is_backward = FALSE
)
```

**Arguments**

sourceIm	Reference image.
destIm	Reference image.
smoothness	Smoothness of estimated displacement field.
precision	Precision required for algorithm convergence.
nb_scales	Number of scales used to estimate the displacement field.
iteration_max	Maximum number of iterations allowed for one scale.
is_backward	If false, match $I2(X + U(X)) = I1(X)$ , else match $I2(X) = I1(X - U(X))$ .

---

display	<i>Display object using CImg library</i>
---------	--

---

**Description**

CImg has its own functions for fast, interactive image plotting. Use this if you get frustrated with slow rendering in RStudio. Note that you need X11 library to use this function.

**Usage**

```
display(x, ...)
```

**Arguments**

x	an image or a list of images
...	ignored

**See Also**

display.cimg, display.imlist

---

display.cimg	<i>Display image using CImg library</i>
--------------	---

---

**Description**

Press escape or close the window to exit. Note that you need X11 library to use this function.

**Usage**

```
## S3 method for class 'cimg'
display(x, ..., rescale = TRUE)
```

**Arguments**

x	an image (cimg object)
...	ignored
rescale	if true pixel values are rescaled to [0-1] (default TRUE)

**Examples**

```
##Not run: interactive only
##display(boats,TRUE) #Normalisation on
##display(boats/2,TRUE) #Normalisation on, so same as above
##display(boats,FALSE) #Normalisation off
##display(boats/2,FALSE) #Normalisation off, so different from above
```

---

display.list	<i>Display image list using CImg library</i>
--------------	--

---

**Description**

Click on individual images to zoom in.

**Usage**

```
## S3 method for class 'list'
display(x, ...)
```

**Arguments**

x	a list of cimg objects
...	ignored

**Examples**

```
##Not run: interactive only
## imgradient(boats,"xy") %>% display
```

---

distance\_transform      *Compute Euclidean distance function to a specified value.*

---

### Description

The distance transform implementation has been submitted by A. Meijster, and implements the article 'W.H. Hesselink, A. Meijster, J.B.T.M. Roerdink, "A general algorithm for computing distance transforms in linear time.", In: Mathematical Morphology and its Applications to Image and Signal Processing, J. Goutsias, L. Vincent, and D.S. Bloomberg (eds.), Kluwer, 2000, pp. 331-340.' The submitted code has then been modified to fit CImg coding style and constraints.

### Usage

```
distance_transform(im, value, metric = 2L)
```

### Arguments

im	an image
value	Reference value.
metric	Type of metric. Can be <tt>0=Chebyshev   1=Manhattan   2=Euclidean   3=Squared-euclidean </tt>.

### Examples

```
imd <- function(x,y) imdirac(c(100,100,1,1),x,y)
#Image is three white dots
im <- imd(20,20)+imd(40,40)+imd(80,80)
plot(im)
#How far are we from the nearest white dot?
distance_transform(im,1) %>% plot
```

---

draw\_circle      *Draw circle on image*

---

### Description

Add circle or circles to an image. Like other native CImg drawing functions, this is meant to be basic but fast. Use implot for flexible drawing.

### Usage

```
draw_circle(im, x, y, radius, color = "white", opacity = 1, filled = TRUE)
```

**Arguments**

im	an image
x	x coordinates
y	y coordinates
radius	radius (either a single value or a vector of length equal to length(x))
color	either a string ("red"), a character vector of length equal to x, or a matrix of dimension length(x) times spectrum(im)
opacity	scalar or vector of length equal to length(x). 0: transparent 1: opaque.
filled	fill circle (default TRUE)

**Value**

an image

**Author(s)**

Simon Barthelme

**See Also**

imshow

**Examples**

```
draw_circle(boats,c(50,100),c(150,200),30,"darkgreen") %>% plot
draw_circle(boats,125,60,radius=30,col=c(0,1,0),opacity=.2,filled=TRUE) %>% plot
```

---

draw\_rect

*Draw rectangle on image*

---

**Description**

Add a rectangle to an image. Like other native CImg drawing functions, this is meant to be basic but fast. Use imshow for flexible drawing.

**Usage**

```
draw_rect(im, x0, y0, x1, y1, color = "white", opacity = 1, filled = TRUE)
```

**Arguments**

im	an image
x0	x coordinate of the bottom-left corner
y0	y coordinate of the bottom-left corner
x1	x coordinate of the top-right corner
y1	y coordinate of the top-right corner
color	either a vector, or a string (e.g. "blue")
opacity	0: transparent 1: opaque.
filled	fill rectangle (default TRUE)

**Value**

an image

**Author(s)**

Simon Barthelme

**See Also**

imshow, draw\_circle

**Examples**

```
draw_rect(boats,1,1,50,50,"darkgreen") %>% plot
```

---

draw\_text

*Draw text on an image*

---

**Description**

Like other native CImg drawing functions, this is meant to be basic but fast. Use imshow for flexible drawing.

**Usage**

```
draw_text(im, x, y, text, color, opacity = 1, fsize = 20)
```

**Arguments**

im	an image
x	x coord.
y	y coord.
text	text to draw (a string)
color	either a vector or a string (e.g. "red")
opacity	0: transparent 1: opaque.
fsize	font size (in pix., default 20)

**Value**

an image

**Author(s)**

Simon Barthelme

**See Also**

imshow, draw\_circle, draw\_rect

**Examples**

```
draw_text(boats,100,100,"Some text",col="black") %>% plot
```

---

erode	<i>Erode/dilate image by a structuring element.</i>
-------	---

---

**Description**

Erode/dilate image by a structuring element.

**Usage**

```
erode(im, mask, boundary_conditions = TRUE, real_mode = FALSE)
erode_rect(im, sx, sy, sz = 1L)
erode_square(im, size)
dilate(im, mask, boundary_conditions = TRUE, real_mode = FALSE)
dilate_rect(im, sx, sy, sz = 1L)
dilate_square(im, size)
```

```
mopening(im, mask, boundary_conditions = TRUE, real_mode = FALSE)
mopening_square(im, size)
mclosing_square(im, size)
mclosing(im, mask, boundary_conditions = TRUE, real_mode = FALSE)
```

### Arguments

<code>im</code>	an image
<code>mask</code>	Structuring element.
<code>boundary_conditions</code>	Boundary conditions. If FALSE, pixels beyond image boundaries are considered to be 0, if TRUE one. Default: TRUE.
<code>real_mode</code>	If TRUE, perform erosion as defined on the reals. If FALSE, perform binary erosion (default FALSE).
<code>sx</code>	Width of the structuring element.
<code>sy</code>	Height of the structuring element.
<code>sz</code>	Depth of the structuring element.
<code>size</code>	size of the structuring element.

### Functions

- `erode_rect()`: Erode image by a rectangular structuring element of specified size.
- `erode_square()`: Erode image by a square structuring element of specified size.
- `dilate()`: Dilate image by a structuring element.
- `dilate_rect()`: Dilate image by a rectangular structuring element of specified size
- `dilate_square()`: Dilate image by a square structuring element of specified size
- `mopening()`: Morphological opening (erosion followed by dilation)
- `mopening_square()`: Morphological opening by a square element (erosion followed by dilation)
- `mclosing_square()`: Morphological closing by a square element (dilation followed by erosion)
- `mclosing()`: Morphological closing (dilation followed by erosion)

### Examples

```
fname <- system.file('extdata/Leonardo_Birds.jpg', package='imager')
im <- load.image(fname) %>% grayscale
outline <- threshold(-im, "95%")
plot(outline)
mask <- imfill(5,10, val=1) #Rectangular mask
```

```

plot(erode(outline,mask))
plot(erode_rect(outline,5,10)) #Same thing
plot(erode_square(outline,5))
plot(dilate(outline,mask))
plot(dilate_rect(outline,5,10))
plot(dilate_square(outline,5))

```

---

extract_patches	<i>Extract image patches and return a list</i>
-----------------	--

---

### Description

Patches are rectangular (cubic) image regions centered at  $cx,cy$  ( $cz$ ) with width  $wx$  and height  $wy$  (opt. depth  $wz$ ) **WARNINGS:** - values outside of the image region are subject to boundary conditions. The default is to set them to 0 (Dirichlet), other boundary conditions are listed below. - widths and heights should be odd integers (they're rounded up otherwise).

### Usage

```
extract_patches(im, cx, cy, wx, wy, boundary_conditions = 0L)
```

```
extract_patches3D(im, cx, cy, cz, wx, wy, wz, boundary_conditions = 0L)
```

### Arguments

<code>im</code>	an image
<code>cx</code>	vector of x coordinates for patch centers
<code>cy</code>	vector of y coordinates for patch centers
<code>wx</code>	vector of patch widths (or single value)
<code>wy</code>	vector of patch heights (or single value)
<code>boundary_conditions</code>	integer. Can be 0 (Dirichlet, default), 1 (Neumann) 2 (Periodic) 3 (mirror).
<code>cz</code>	vector of z coordinates for patch centers
<code>wz</code>	vector of coordinates for patch depth

### Value

a list of image patches (cimg objects)

### Functions

- `extract_patches3D()`: Extract 3D patches

### Examples

```

#2 patches of size 5x5 located at (10,10) and (10,20)
extract_patches(boats,c(10,10),c(10,20),5,5)

```

---

**FFT***Compute the Discrete Fourier Transform of an image*

---

**Description**

This function is equivalent to R's builtin `fft`, up to normalisation (R's version is unnormalised, this one is). It calls `CImg`'s implementation. Important note: `FFT` will compute a multidimensional Fast Fourier Transform, using as many dimensions as you have in the image, meaning that if you have a colour video, it will perform a 4D FFT. If you want to compute separate FFTs across channels, use `imsplit`.

**Usage**

```
FFT(im.real, im.imag, inverse = FALSE)
```

**Arguments**

<code>im.real</code>	The real part of the input (an image)
<code>im.imag</code>	The imaginary part (also an image. If missing, assume the signal is real).
<code>inverse</code>	If true compute the inverse FFT (default: FALSE)

**Value**

a list with components "real" (an image) and "imag" (an image), corresponding to the real and imaginary parts of the transform

**Author(s)**

Simon Barthelme

**Examples**

```
im <- as.cimg(function(x,y) sin(x/5)+cos(x/4)*sin(y/2),128,128)
ff <- FFT(im)
plot(ff$real,main="Real part of the transform")
plot(ff$imag,main="Imaginary part of the transform")
sqrt(ff$real^2+ff$imag^2) %>% plot(main="Power spectrum")
#Check that we do get our image back
check <- FFT(ff$real,ff$imag,inverse=TRUE)$real #Should be the same as original
mean((check-im)^2)
```

---

flatten.alpha	<i>Flatten alpha channel</i>
---------------	------------------------------

---

**Description**

Flatten alpha channel

**Usage**

```
flatten.alpha(im, bg = "white")
```

**Arguments**

**im** an image (with 4 RGBA colour channels)

**bg** background: either an RGB image, or a vector of colour values, or a string (e.g. "blue"). Default: white background.

**Value**

a blended image

**Author(s)**

Simon Barthelme

**See Also**

rm.alpha

**Examples**

```
#Add alpha channel
alpha <- Xc(grayscale(boats))/width(boats)
boats.a <- imlist(boats,alpha) %>% imappend("c")
flatten.alpha(boats.a) %>% plot
flatten.alpha(boats.a,"darkgreen") %>% plot
```

---

frames	<i>Split a video into separate frames</i>
--------	---

---

**Description**

Split a video into separate frames

**Usage**

```
frames(im, index, drop = FALSE)
```

**Arguments**

im	an image
index	which channels to extract (default all)
drop	if TRUE drop extra dimensions, returning normal arrays and not cimg objects

**Value**

a list of frames

**See Also**

channels

---

get.locations	<i>Return coordinates of subset of pixels</i>
---------------	---

---

**Description**

Typical use case: you want the coordinates of all pixels with a value above a certain threshold

**Usage**

```
get.locations(im, condition)
```

**Arguments**

im	the image
condition	a function that takes scalars and returns logicals

**Value**

coordinates of all pixels such that condition(pixel) == TRUE

**Author(s)**

Simon Barthelme

**Examples**

```
im <- as.cimg(function(x,y) x+y,10,10)
get.locations(im,function(v) v < 4)
get.locations(im,function(v) v^2 + 3*v - 2 < 30)
```

---

get.stencil

*Return pixel values in a neighbourhood defined by a stencil*


---

**Description**

A stencil defines a neighbourhood in an image (for example, the four nearest neighbours in a 2d image). This function centers the stencil at a certain pixel and returns the values of the neighbouring pixels.

**Usage**

```
get.stencil(im, stencil, ...)
```

**Arguments**

im	an image
stencil	a data.frame with values dx,dy,[dz],[dcc] defining the neighbourhood
...	where to center, e.g. x = 100,y = 10,z=3,cc=1

**Value**

pixel values in neighbourhood

**Author(s)**

Simon Barthelme

**Examples**

```
#The following stencil defines a neighbourhood that
#include the next pixel to the left (delta_x = -1) and the next pixel to the right (delta_x = 1)
stencil <- data.frame(dx=c(-1,1),dy=c(0,0))
im <- as.cimg(function(x,y) x+y,w=100,h=100)
get.stencil(im,stencil,x=50,y=50)
```

```
#A larger neighbourhood that includes pixels upwards and
```

```
#downwards of center (delta_y = -1 and +1)
stencil <- stencil.cross()
im <- as.cimg(function(x,y) x,w=100,h=100)
get.stencil(im,stencil,x=5,y=50)
```

---

get\_gradient                      *Compute image gradient.*

---

### Description

Compute image gradient.

### Usage

```
get_gradient(im, axes = "", scheme = 3L)
```

### Arguments

im	an image
axes	Axes considered for the gradient computation, as a C-string (e.g "xy").
scheme	= Numerical scheme used for the gradient computation: 1 = Backward finite differences 0 = Centered finite differences 1 = Forward finite differences 2 = Using Sobel masks 3 = Using rotation invariant masks 4 = Using Deriche recursive filter. 5 = Using Van Vliet recursive filter.

### Value

a list of images (corresponding to the different directions)

### See Also

imgradient

---

get\_hessian                      *Return image hessian.*

---

### Description

Return image hessian.

### Usage

```
get_hessian(im, axes = "")
```

### Arguments

im	an image
axes	Axes considered for the hessian computation, as a character string (e.g "xy").

---

**grab***Select image regions interactively*

---

**Description**

These functions let you select a shape in an image (a point, a line, or a rectangle) They either return the coordinates of the shape (default), or the contents. In case of lines contents are interpolated. Note that grabLine does not support the "pixset" return type. Note that you need X11 library to use these functions.

**Usage**

```
grabLine(im, output = "coord")
```

```
grabRect(im, output = "coord")
```

```
grabPoint(im, output = "coord")
```

**Arguments**

im                    an image

output                one of "im","pixset","coord","value". Default "coord"

**Value**

Depending on the value of the output parameter. Either a vector of coordinates (output = "coord"), an image (output = "im"), a pixset (output = "pixset"), or a vector of values (output = "value"). grabLine and grabPoint support the "value" output mode and not the "im" output.

**Author(s)**

Simon Barthelme

**See Also**

display

**Examples**

```
##Not run: interactive only
##grabRect(boats)
##grabRect(boats,TRUE)
```

---

grayscale	<i>Convert an RGB image to grayscale</i>
-----------	--

---

### Description

This function converts from RGB images to grayscale

### Usage

```
grayscale(im, method = "Luma", drop = TRUE)
```

### Arguments

im	an RGB image
method	either "Luma", in which case a linear approximation to luminance is used, or "XYZ", in which case the image is assumed to be in sRGB color space and CIE luminance is used.
drop	if TRUE returns an image with a single channel, otherwise keep the three channels (default TRUE)

### Value

a grayscale image (spectrum == 1)

### Examples

```
grayscale(boats) %>% plot
#In many pictures, the difference between Luma and XYZ conversion is subtle
grayscale(boats,method="XYZ") %>% plot
grayscale(boats,method="XYZ",drop=FALSE) %>% dim
```

---

grow	<i>Grow/shrink a pixel set</i>
------	--------------------------------

---

### Description

Grow/shrink a pixel set through morphological dilation/erosion. The default is to use square or rectangular structuring elements, but an arbitrary structuring element can be given as input. A structuring element is a pattern to be moved over the image: for example a 3x3 square. In "shrink" mode, a element of the pixset is retained only if and only the structuring element fits entirely within the pixset. In "grow" mode, the structuring element acts like a neighbourhood: all pixels that are in the original pixset \*or\* in the neighbourhood defined by the structuring element belong the new pixset.

**Usage**

```
grow(px, x, y = x, z = x, boundary = TRUE)
```

```
shrink(px, x, y = x, z = x, boundary = TRUE)
```

**Arguments**

px	a pixset
x	either an integer value, or an image/pixel set.
y	width of the rectangular structuring element (if x is an integer value)
z	depth of the rectangular structuring element (if x is an integer value)
boundary	are pixels beyond the boundary considered to have value TRUE or FALSE (default TRUE)

**Functions**

- shrink(): shrink pixset using erosion

**Examples**

```
#A pixel set:
a <- grayscale(boats) > .8
plot(a)
#Grow by a 8x8 square
grow(a,8) %>% plot
#Grow by a 8x2 rectangle
grow(a,8,2) %>% plot
#Custom structuring element
el <- matrix(1,2,2) %>% as.cimg
all.equal(grow(a,el),grow(a,2))
#Circular structuring element
px.circle(5) %>% grow(a,.) %>% plot

#Sometimes boundary conditions matter
im <- imfill(10,10)
px <- px.all(im)
shrink(px,3,bound=TRUE) %>% plot(main="Boundary conditions: TRUE")
shrink(px,3,bound=FALSE) %>% plot(main="Boundary conditions: FALSE")
```

**Description**

Shortcut, returns the dimensions of an image if it had only one colour channel

**Usage**

```
gsdim(im)
```

**Arguments**

```
im          an image
```

**Value**

```
returns c(dim(im)[1:3],1)
```

**Author(s)**

```
Simon Barthelme
```

**Examples**

```
imnoise(dim=gsdim(boats))
```

---

```
haar
```

```
Compute Haar multiscale wavelet transform.
```

---

**Description**

```
Compute Haar multiscale wavelet transform.
```

**Usage**

```
haar(im, inverse = FALSE, nb_scales = 1L)
```

**Arguments**

```
im          an image  
inverse     Compute inverse transform (default FALSE)  
nb_scales   Number of scales used for the transform.
```

**Examples**

```
#Image compression: set small Haar coefficients to 0  
hr <- haar(boats,nb=3)  
mask.low <- threshold(abs(hr),"75%")  
mask.high <- threshold(abs(hr),"95%")  
haar(hr*mask.low,inverse=TRUE,nb=3) %>% plot(main="75% compression")  
haar(hr*mask.high,inverse=TRUE,nb=3) %>% plot(main="95% compression")
```

---

highlight	<i>Highlight pixel set on image</i>
-----------	-------------------------------------

---

**Description**

Overlay an image plot with the contours of a pixel set. Note that this function doesn't do the image plotting, just the highlighting.

**Usage**

```
highlight(px, col = "red", ...)
```

**Arguments**

px	a pixel set
col	color of the contours
...	passed to the "lines" function

**Author(s)**

Simon Barthelme

**See Also**

colorise, another way of highlighting stuff

**Examples**

```
#Select similar pixels around point (180,200)
px <- px.flood(boats,180,200,sigma=.08)
plot(boats)
#Highlight selected set
highlight(px)
px.flood(boats,18,50,sigma=.08) %>% highlight(col="white",lwd=3)
```

---

hough_circle	<i>Circle detection using Hough transform</i>
--------------	---

---

**Description**

Detects circles of known radius in a pixset. The output is an image where the pixel value at (x,y) represents the amount of evidence for the presence of a circle of radius r at position (x,y). NB: in the current implementation, does not detect circles centred outside the limits of the pixset.

**Usage**

```
hough_circle(px, radius)
```

**Arguments**

```
px          a pixset (e.g., the output of a Canny detector)
radius      radius of circle
```

**Value**

a histogram of Hough scores, with the same dimension as the original image.

**Author(s)**

Simon Barthelme

**Examples**

```
im <- load.example('coins')
px <- cannyEdges(im)
#Find circles of radius 20
hc <- hough_circle(px,20)
plot(hc)
#Clean up, run non-maxima suppression
nms <- function(im,sigma) { im[dilate_square(im,sigma) != im] <- 0; im}
hc.clean <- isoblur(hc,3) %>% nms(50)
#Top ten matches
df <- as.data.frame(hc.clean) %>%
dplyr::arrange(desc(value)) %>% head(10)
with(df,circles(x,y,20,fg="red",lwd=3))
```

---

hough\_line

*Hough transform for lines*

---

**Description**

Two algorithms are used, depending on the input: if the input is a pixset then the classical Hough transform is used. If the input is an image, then a faster gradient-based heuristic is used. The method returns either an image (the votes), or a data.frame. In both cases the parameterisation used is the Hesse normal form (theta,rho), where a line is represented as the set of values such that  $\cos(\text{theta}) * x + \sin(\text{theta}) * y = \text{rho}$ . Here theta is an angle and rho is a distance. The image form returns a histogram of scores in (rho,theta) space, where good candidates for lines have high scores. The data.frame form may be more convenient for further processing in R: each line represents a pair (rho,theta) along with its score. If the 'shift' argument is true, then the image is assumed to start at x=1,y=1 (more convenient for plotting in R). If false, the image begins at x=0,y=0 and in both cases the origin is at the top left.

**Usage**

```
hough_line(im, ntheta = 100, data.frame = FALSE, shift = TRUE)
```

**Arguments**

im	an image or pixset
ntheta	number of bins along theta (default 100)
data.frame	return a data.frame? (default FALSE)
shift	if TRUE, image is considered to begin at (x=1,y=1).

**Value**

either an image or a data.frame

**Author(s)**

Simon Barthelme

**Examples**

```
#Find the lines along the boundary of a square
px <- px.square(30,80,80) %>% boundary
plot(px)
#Hough transform
hough_line(px,ntheta=200) %>% plot

df <- hough_line(px,ntheta=800,data.frame=TRUE)
#Plot lines with the highest score
plot(px)
with(subset(df,score > quantile(score,.9995)),nline(theta,rho,col="red"))

plot(boats)
df <- hough_line(boats,ntheta=800,data=TRUE)
```

---

idply

*Split an image along axis, map function, return a data.frame*


---

**Description**

Shorthand for imsplit followed by purrr::map\_df

**Usage**

```
idply(im, axis, fun, ...)
```

**Arguments**

im	image
axis	axis for the split (e.g "c")
fun	function to apply
...	extra arguments to function fun

**Examples**

```
idply(boats,"c",mean) #mean luminance per colour channel
```

---

iiply	<i>Split an image, apply function, recombine the results as an image</i>
-------	--

---

**Description**

This is just `imsplit` followed by `purrr::map` followed by `imappend`

**Usage**

```
iiply(im, axis, fun, ...)
```

**Arguments**

im	image
axis	axis for the split (e.g "c")
fun	function to apply
...	extra arguments to function fun

**Examples**

```
##' #Normalise colour channels separately, recombine
iiply(boats,"c",function(v) (v-mean(v))/sd(v)) %>% plot
```

---

ilply *Split an image along axis, apply function, return a list*

---

### Description

Shorthand for `imsplit` followed by `purrr::map`

### Usage

```
ilply(im, axis, fun, ...)
```

### Arguments

<code>im</code>	image
<code>axis</code>	axis for the split (e.g "c")
<code>fun</code>	function to apply
<code>...</code>	extra arguments for function <code>fun</code>

### Examples

```
parrots <- load.example("parrots")
ilply(parrots,"c",mean) #mean luminance per colour channel
```

---

imager *imager: an R library for image processing, based on CImg*

---

### Description

CImg by David Tschumperle is a C++ library for image processing. It provides most common functions for image manipulation and filtering, as well as some advanced algorithms. `imager` makes these functions accessible from R and adds many utilities for accessing and working with image data from R. You should install `ImageMagick` if you want support for image formats beyond PNG and JPEG, and `ffmpeg` if you need to work with videos (in which case you probably also want to take a look at experimental package `imagerstreams` on github). Package documentation is available at <http://asgr.github.io/imager/>.

---

`imager.combine`*Combining images*

---

**Description**

These functions take a list of images and combine them by adding, multiplying, taking the parallel min or max, etc. The max. in absolute value of  $(x_1, x_2)$  is defined as  $x_1$  if  $(|x_1| > |x_2|)$ ,  $x_2$  otherwise. It's useful for example in getting the most extreme value while keeping the sign. "parsort", "parrank" and "parorder" aren't really reductions because they return a list of the same size. They perform a pixel-wise sort (resp. order and rank) across the list.

**Usage**`add(x, na.rm = FALSE)``wsum(x, w, na.rm = FALSE)``average(x, na.rm = FALSE)``mult(x, na.rm = FALSE)``parmax(x, na.rm = FALSE)``parmax.abs(x)``parmin.abs(x)``parmin(x, na.rm = FALSE)``enorm(x)``parmed(x, na.rm = FALSE)``parvar(x, na.rm = FALSE)``parsd(x, na.rm = FALSE)``parall(x)``parany(x)``equal(x)``which.parmax(x)``which.parmin(x)`

```
parsort(x, increasing = TRUE)
```

```
parorder(x, increasing = TRUE)
```

```
parrank(x, increasing = TRUE)
```

### Arguments

x	a list of images
na.rm	ignore NAs (default FALSE)
w	weights (must be the same length as the list)
increasing	if TRUE, sort in increasing order (default TRUE)

### Details

parvar returns an unbiased estimate of the variance (as in the base var function). parsd returns the square root of parvar.

To correctly use multiple threads users should set 'nthreads' in [cimg.use.openmp](#). You also need to be careful that this is not higher than the value in the system environment variable OMP\_THREAD\_LIMIT (this can be checked with Sys.getenv('OMP\_THREAD\_LIMIT')). The OMP\_THREAD\_LIMIT thread limit usually needs to be correctly set before launching R, so using Sys.setenv once a session has started is not certain to work.

### Functions

- add(): Add images
- wsum(): Weighted sum of images
- average(): Average images
- mult(): Multiply images (pointwise)
- parmax(): Parallel max over images
- parmax.abs(): Parallel max in absolute value over images,
- parmin.abs(): Parallel min in absolute value over images,
- parmin(): Parallel min over images
- enorm(): Euclidean norm (i.e.  $\sqrt{A^2 + B^2 + \dots}$ )
- parmed(): Parallel Median over images
- parvar(): Variance
- parsd(): Std. deviation
- parall(): Parallel all (for pixsets)
- parany(): Parallel any (for pixsets)
- equal(): Test equality
- which.parmax(): index of parallel maxima
- which.parmin(): index of parallel minima
- parsort(): pixel-wise sort
- parorder(): pixel-wise order
- parrank(): pixel-wise rank

**Author(s)**

Simon Barthelme

**See Also**

imsplit,Reduce

**Examples**

```

im1 <- as.cimg(function(x,y) x,50,50)
im2 <- as.cimg(function(x,y) y,50,50)
im3 <- as.cimg(function(x,y) cos(x/10),50,50)
l <- imlist(im1,im2,im3)
add(l) %>% plot #Add the images
average(l) %>% plot #Average the images
mult(l) %>% plot #Multiply
wsum(l,c(.1,8,.1)) %>% plot #Weighted sum
parmax(l) %>% plot #Parallel max
parmin(l) %>% plot #Parallel min
parmed(l) %>% plot #Parallel median
parsd(l) %>% plot #Parallel std. dev
#parsort can also be used to produce parallel max. and min
(parsort(l)[[1]]) %>% plot("Parallel min")
(parsort(l)[[length(l)]]) %>% plot("Parallel max")
#Resize boats so the next examples run faster
im <- imresize(boats,.5)
#Edge detection (Euclidean norm of gradient)
imgradient(im,"xy") %>% enorm %>% plot
#Pseudo-artistic effects
l <- map_il(seq(1,35,5),~ boxblur(im,.))
parmin(l) %>% plot
average(l) %>% plot
mult(l) %>% plot
#At each pixel, which colour channel has the maximum value?
imsplit(im,"c") %>% which.parmax %>% table
#Same thing using parorder (ties are broken differently)!!!
imsplit(im,"c") %>% { parorder(.)[[length(.)]] } %>% table

```

---

imager.replace

*Replace part of an image with another*


---

**Description**

These replacement functions let you modify part of an image (for example, only the red channel). Note that cimg objects can also be treated as regular arrays and modified using the usual [] operator.

**Usage**

```
channel(x, ind) <- value
```

```
R(x) <- value
```

```
G(x) <- value
```

```
B(x) <- value
```

```
frame(x, ind) <- value
```

**Arguments**

x	an image to be modified
ind	an index
value	the image to insert

**Functions**

- `channel(x, ind) <- value`: Replace image channel
- `R(x) <- value`: Replace red channel
- `G(x) <- value`: Replace green channel
- `B(x) <- value`: Replace blue channel
- `frame(x, ind) <- value`: Replace image frame

**See Also**

`imdraw`

**Examples**

```
boats.cp <- boats
#Set the green channel in the boats image to 0
G(boats.cp) <- 0
#Same thing, more verbose
channel(boats.cp,2) <- 0
#Replace the red channel with noise
R(boats.cp) <- imnoise(width(boats),height(boats))
#A new image with 5 frames
tmp <- imfill(10,10,5)
#Fill the third frame with noise
frame(tmp,3) <- imnoise(10,10)
```

---

imager.subset	<i>Array subset operator for cimg objects</i>
---------------	---

---

### Description

Internally cimg objects are 4D arrays (stored in x,y,z,c mode) but often one doesn't need all dimensions. This is the case for instance when working on grayscale images, which use only two. The array subset operator works like the regular array [] operator, but it won't force you to use all dimensions. There are easier ways of accessing image data, for example imsub, channels, R, G, B, and the like.

### Arguments

x	an image (cimg object)
drop	if true return an array, otherwise return an image object (default FALSE)
...	subsetting arguments

### See Also

imsub, which provides a more convenient interface, autocrop, imdraw

### Examples

```
im <- imfill(4,4)
dim(im) #4 dimensional, but the last two ones are singletons
im[,1,,] <- 1:4 #Assignment the standard way
im[,1] <- 1:4 #Shortcut
as.matrix(im)
im[1:2,]
dim(boats)
#Arguments will be recycled, as in normal array operations
boats[1:2,1:3,] <- imnoise(2,3) #The same noise array is replicated over the three channels
```

---

imappend	<i>Combine a list of images into a single image</i>
----------	---

---

### Description

All images will be concatenated along the x,y,z, or c axis.

### Usage

```
imappend(imlist, axis)
```

**Arguments**

imlist            a list of images (all elements must be of class cimg)  
 axis             the axis along which to concatenate (for example 'c')

**See Also**

imsplit (the reverse operation)

**Examples**

```
imappend(list(boats,boats),"x") %>% plot
imappend(list(boats,boats),"y") %>% plot
purrr::map(1:3, ~imnoise(100,100)) %>% imappend("c") %>% plot
boats.gs <- grayscale(boats)
purrr::map(seq(1,5,l=3),function(v) isoblur(boats.gs,v)) %>% imappend("c") %>% plot
#imappend also works on pixsets
imsplit(boats > .5,"c") %>% imappend("x") %>% plot
```

---

imchange

*Modify parts of an image*


---

**Description**

A shortcut for modifying parts of an image, using imeval syntax. See doc for imeval first. As part of a pipe, avoids the creating of intermediate variables.

**Usage**

```
imchange(obj, where, fo, env = parent.frame())
```

**Arguments**

obj              an image or imlist  
 where            where to modify. a pixset, or a formula (in imeval syntax) that evaluates to a pixset.  
 fo                a formula (in imeval syntax) used to modify the image part  
 env              evaluation environment (see imeval)

**Value**

a modified image

**Author(s)**

Simon Barthelme

**See Also**

imeval

**Examples**

```

#Set border to 0:
imchange(boats,px.borders(boats,10),~ 0) %>% plot
#Eq. to
im <- boats
im[px.borders(im,10)] <- 0
#Using formula syntax
imchange(boats,~ px.borders(.,10),~ 0)
#Replace with grayscale ramp
imchange(boats,~ px.borders(.,10),~ xs) %>% plot
#Kill red channel in image
imchange(boats,~ c==1,~ 0) %>% plot
#Shit hue by an amount depending on eccentricity
load.example("parrots") %>%
  RGBtoHSL %>%
  imchange(~ c==1,~ .+80*exp(-(rho/550)^2) ) %>%
  HSLtoRGB %>%
  plot

```

---

imcoord

*Coordinates as images*


---

**Description**

These functions return pixel coordinates for an image, as an image. All is made clear in the examples (hopefully)

**Usage**

Xc(im)

Yc(im)

Zc(im)

Cc(im)

**Arguments**

im            an image

**Value**

another image of the same size, containing pixel coordinates

**Functions**

- Xc(): X coordinates
- Yc(): Y coordinates
- Zc(): Z coordinates
- Cc(): C coordinates

**See Also**

as.cimg.function, pixel.grid

**Examples**

```
im <- imfill(5,5) #An image
Xc(im) #An image of the same size, containing the x coordinates of each pixel
Xc(im) %>% imrow(1)
Yc(im) %>% imrow(3) #y is constant along rows
Yc(im) %>% imcol(1)
#Mask bits of the boats image:
plot(boats*(Xc(boats) < 100))
plot(boats*(dnorm(Xc(boats),m=100,sd=30))) #Gaussian window
```

---

imdirac

*Generates a "dirac" image, i.e. with all values set to 0 except one.*

---

**Description**

This small utility is useful to examine the impulse response of a filter

**Usage**

```
imdirac(dims, x, y, z = 1, cc = 1)
```

**Arguments**

dims	a vector of image dimensions, or an image whose dimensions will be used. If dims has length < 4 some guesswork will be used (see examples and ?as.cimg.array)
x	where to put the dirac (x coordinate)
y	y coordinate
z	z coordinate (default 1)
cc	colour coordinate (default 1)

**Value**

an image

**Author(s)**

Simon Barthelme

**Examples**

```
#Explicit settings of all dimensions
imdirac(c(50,50,1,1),20,20)
imdirac(c(50,50),20,20) #Implicit
imdirac(c(50,50,3),20,20,cc=2) #RGB
imdirac(c(50,50,7),20,20,z=2) #50x50 video with 7 frames
#Impulse response of the blur filter
imdirac(c(50,50),20,20) %>% isoblur(sigma=2) %>% plot
#Impulse response of the first-order Deriche filter
imdirac(c(50,50),20,20) %>% deriche(sigma=2,order=1,axis="x") %>% plot
##NOT RUN, interactive only
##Impulse response of the blur filter in space-time
##resp <- imdirac(c(50,50,100),x=25,y=25,z=50) %>% isoblur(16)
###Normalise to 0...255 and play as video
##renorm(resp) %>% play(normalise=FALSE)
```

---

imdraw

*Draw image on another image*


---

**Description**

Draw image on another image

**Usage**

```
imdraw(im, sprite, x = 1, y = 1, z = 1, opacity = 1)
```

**Arguments**

im	background image
sprite	sprite to draw on background image
x	location
y	location
z	location
opacity	transparency level (default 1)

**Author(s)**

Simon Barthelme

**See Also**

imager.combine, for different ways of combining images

**Examples**

```
im <- load.example("parrots")
boats.small <- imresize(boats,.5)
#I'm aware the result is somewhat ugly
imdraw(im,boats.small,x=400,y=10,opacity=.7) %>% plot
```

---

imeval

*Evaluation in an image context*


---

**Description**

imeval does for images what "with" does for data.frames, namely contextual evaluation. It provides various shortcuts for pixel-wise operations. imdo runs imeval, and reshapes the output as an image of the same dimensions as the input (useful for functions that return vectors). imeval takes inspiration from purrr::map in using formulas for defining anonymous functions using the "." argument. Usage is made clear (hopefully) in the examples. The old version of imeval used CImg's internal math parser, but has been retired.

**Usage**

```
imeval(obj, ..., env = parent.frame())
```

```
imdo(obj, form)
```

**Arguments**

obj	an image, pixset or imlist
...	one or more formula objects, defining anonymous functions that will be evaluated with the image as first argument (with extra contextual variables added to the evaluation context)
env	additional variables (defaults to the calling environment)
form	a single formula

**Functions**

- imdo(): run imeval and reshape

**Author(s)**

Simon Barthelme

**See Also**

imchange, which modifies specific parts of an image

**Examples**

```
## Computing mean absolute deviation
imeval(boats, ~ mean(abs(.-median(.))))
##Equivalent to:
mean(abs(boats-median(boats)))
##Two statistics
imeval(boats,mad= ~ mean(abs(.-median(.))),sd= ~ sd(.))
##imeval can precompute certain quantities, like the x or y coord. of each pixel
imeval(boats,~ x) %>% plot
##same as Xc(boats) %>% plot
## Other predefined quantities:
##w is width, h is height
imeval(boats,~ x/w) %>% range
##It defines certain transformed coordinate systems:
##Scaled x,y,z
## xs=x/w
## ys=y/h
##Select upper-left quadrant (returns a pixset)
imeval(boats,~ xs<.5 & ys < .5) %>% plot
##Fade effect
imeval(boats,~ xs*. ) %>% plot
## xc and yc are another set of transformed coordinates
## where xc=0,yc=0 is the image center
imeval(boats,~ (abs(xc)/w)*. ) %>% plot

##rho, theta: circular coordinates. rho is distance to center (in pix.), theta angle
##Gaussian mask with sd 10 pix.
blank <- imfill(30,30)
imeval(blank,~ dnorm(rho,sd=w/3)) %>% plot(int=FALSE)
imeval(blank,~ theta) %>% plot
##imeval is made for interactive use, meaning it
##accesses the environment it got called from, e.g. this works:
f <- function()
{
  im1 <- imfill(3,3,val=1)
  im2 <- imfill(3,3,val=3)

  imeval(im1,~ .+im2)
}
f()
##imeval accepts lists as well
map_il(1:3, ~ isoblur(boats,.)) %>%
  imeval(~ xs*. ) %>%
  plot

##imeval is useful for defining pixsets:
##here, all central pixels that have value under the median
```

```

grayscale(boats) %>%
  imeval(~ (. > median(.)) & rho < 150) %>%
  plot
##other abbreviations are defined:
##s for imshift, b for isoblur, rot for imrotate.
##e.g.
imeval(boats, ~ .*s(.,3)) %>% plot

#The rank function outputs a vector
grayscale(boats) %>% rank %>% class
#Auto-reshape into an image
grayscale(boats) %>% imdo(~ rank(.)) %>% plot
#Note that the above performs histogram normalisation

#Also works on lists
imsplit(boats,"c") %>% imdo( ~ rank(.)) %>% imappend("c") %>% plot

```

---

imfill

---

*Create an image of custom size by filling in repeated values*


---

## Description

This is a convenience function for quickly creating blank images, or images filled with a specific colour. See examples. If val is a logical value, creates a pixset instead.

## Usage

```
imfill(x = 1, y = 1, z = 1, val = 0, dim = NULL)
```

## Arguments

x	width (default 1)
y	height (default 1)
z	depth (default 1)
val	fill-in values. Either a single value (for grayscale), or RGB values for colour, or a character string for a colour (e.g. "blue")
dim	dimension vector (optional, alternative to specifying x,y,z)

## Value

an image object (class cimg)

## Author(s)

Simon Barthelme

**Examples**

```

imfill(20,20) %>% plot #Blank image of size 20x20
imfill(20,20,val=c(1,0,0)) %>% plot #All red image
imfill(20,20,val="red") %>% plot #Same, using R colour name
imfill(3,3,val=FALSE) #Pixset
imfill(dim=dim(boats)) #Blank image of the same size as the boats image

```

---

imgradient

*Compute image gradient*


---

**Description**

Light interface for `get_gradient`. Refer to `get_gradient` for details on the computation.

**Usage**

```
imgradient(im, axes = "xy", scheme = 3)
```

**Arguments**

<code>im</code>	an image of class <code>cimg</code>
<code>axes</code>	direction along which to compute the gradient. Either a single character (e.g. "x"), or multiple characters (e.g. "xyz"). Default: "xy"
<code>scheme</code>	numerical scheme (default '3', rotation invariant)

**Value**

an image or a list of images, depending on the value of "axes"

**Author(s)**

Simon Barthelme

**Examples**

```

grayscale(boats) %>% imgradient("x") %>% plot
imgradient(boats,"xy") #Returns a list

```

---

imhessian                      *Compute image hessian.*

---

**Description**

Compute image hessian.

**Usage**

```
imhessian(im, axes = c("xx", "xy", "yy"))
```

**Arguments**

im	an image
axes	Axes considered for the hessian computation, as a character string (e.g "xy" corresponds to $d/(dx*dy)$ ). Can be a list of axes. Default: xx,xy,yy

**Value**

an image, or a list of images

**Examples**

```
imhessian(boats,"xy") %>% plot(main="Second-derivative, d/(dx*dy)")
```

---

iminfo                              *Return information on image file*

---

**Description**

This function calls ImageMagick's "identify" utility on an image file to get some information. You need ImageMagick on your path for this to work.

**Usage**

```
iminfo(fname)
```

**Arguments**

fname	path to a file
-------	----------------

**Value**

a list with fields name, format, width (pix.), height (pix.), size (bytes)

**Author(s)**

Simon Barthelme

**Examples**

```
## Not run:
someFiles <- dir("*.png") #Find all PNGs in directory
iminfo(someFiles[1])
#Get info on all files, as a data frame
info <- purrr::map_df(someFiles,function(v) iminfo(v) %>% as.data.frame)

## End(Not run)
```

---

**imlap***Compute image Laplacian*

---

**Description**

The Laplacian is the sum of second derivatives, approximated here using finite differences.

**Usage**

```
imlap(im)
```

**Arguments**

**im**                    an image

**Examples**

```
imlap(boats) %>% plot
```

---

**imlist***Image list*

---

**Description**

An imlist object is simply a list of images (of class cim). For convenience, some generic functions are defined that wouldn't work on plain lists, like plot, display and as.data.frame DEPRECATION NOTE: in v0.30 of imager, the original behaviour of the "imlist" function was to take a list and turn it into an image list. This behaviour has now been changed to make "imlist" be more like "list". If you wish to turn a list into an image list, use as.imlist.

**Usage**

```
imlist(...)
```

**Arguments**

```
...          images to be included in the image list
```

**See Also**

```
plot.imlist, display.imlist, as.data.frame.imlist
```

**Examples**

```
imlist(a=imfill(3,3),b=imfill(10,10))  
imsplit(boats,"x",6)  
imsplit(boats,"x",6) %>% plot
```

---

imnoise	<i>Generate (Gaussian) white-noise image</i>
---------	--

---

**Description**

A white-noise image is an image where all pixel values are drawn IID from a certain distribution. Here they are drawn from a Gaussian.

**Usage**

```
imnoise(x = 1, y = 1, z = 1, cc = 1, mean = 0, sd = 1, dim = NULL)
```

**Arguments**

x	width
y	height
z	depth
cc	spectrum
mean	mean pixel value (default 0)
sd	std. deviation of pixel values (default 1)
dim	dimension vector (optional, alternative to specifying x,y,z,cc)

**Value**

a cimg object

**Author(s)**

Simon Barthelme

## Examples

```
imnoise(100,100,cc=3) %>% plot(main="White noise in RGB")
imnoise(100,100,cc=3) %>% isoblur(5) %>% plot(main="Filtered (non-white) noise")
imnoise(dim=dim(boats)) #Noise image of the same size as the boats image
```

---

implot

*Plot objects on image using base graphics*


---

## Description

This function lets you use an image as a canvas for base graphics, meaning you can use R functions like "text" and "points" to plot things on an image. The function takes as argument an image and an expression, executes the expression with the image as canvas, and outputs the result as an image (of the same size).

## Usage

```
implot(im, expr, ...)
```

## Arguments

im	an image (class cimg)
expr	an expression (graphics code to execute)
...	passed on to plot.cimg, to control the initial rendering of the image (for example the colorscale)

## Value

an image

## Author(s)

Simon Barthelme

## See Also

plot, capture.plot

## Examples

```
## Not run:
b.new <- implot(boats, text(150,50,"Boats!!!", cex=3))
plot(b.new)
#Draw a line on a white background
bg <- imfill(150,150, val=1)
implot(bg, lines(c(50,50), c(50,100), col="red", lwd=4))%>%plot
```

```

#You can change the rendering of the initial image
im <- grayscale(boats)
draw.fun <- function() text(150,50,"Boats!!!",cex=3)
out <- implot(im,draw.fun(),colorscale=function(v) rgb(0,v,v),rescale=FALSE)
plot(out)

## End(Not run)

```

---

imrep

*Replicate images*


---

## Description

Kinda like rep, for images. Copy image n times and (optionally), append.

## Usage

```
imrep(x, n = 1, axis = NULL)
```

## Arguments

x	an image
n	number of replications
axis	axis to append along (one of NULL, "x","y","z","c"). Default: NULL

## Value

either an image or an image list

## Author(s)

Simon Barthelme

## Examples

```

#Result is a list
imrep(boats,3) %>% plot
#Result is an image
imrep(boats,3,"x") %>% plot
#Make an animation by repeating each frame 10x
#map_il(1:5,~ isoblur(boats,.) %>% imrep(10,"z")) %>%
#
#           imappend("z") %>% play

```

---

imrotate	<i>Rotate an image along the XY plane.</i>
----------	--

---

### Description

If `cx` and `cy` aren't given, the default is to centre the rotation in the middle of the image. When `cx` and `cy` are given, the algorithm used is different, and does not change the size of the image.

### Usage

```
imrotate(im, angle, cx, cy, interpolation = 1L, boundary = 0L)
```

### Arguments

<code>im</code>	an image
<code>angle</code>	Rotation angle, in degrees.
<code>cx</code>	Center of rotation along x (default, image centre)
<code>cy</code>	Center of rotation along y (default, image centre)
<code>interpolation</code>	Type of interpolation. One of 0=nearest,1=linear,2=cubic.
<code>boundary</code>	Boundary conditions. One of 0=dirichlet, 1=neumann, 2=periodic

### See Also

`imwarp`, for flexible image warping, which includes rotations as a special case

### Examples

```
imrotate(boats,30) %>% plot
#Shift centre to (20,20)
imrotate(boats,30,cx=20,cy=20) %>% plot
```

---

imsharpen	<i>Sharpen image.</i>
-----------	-----------------------

---

### Description

The default sharpening filter is inverse diffusion. The "shock filter" is a non-linear diffusion that has better edge-preserving properties.

### Usage

```
imsharpen(im, amplitude, type = "diffusion", edge = 1, alpha = 0, sigma = 0)
```

**Arguments**

im	an image
amplitude	Sharpening amplitude (positive scalar, 0: no filtering).
type	Filtering type. "diffusion" (default) or "shock"
edge	Edge threshold (shock filters only, positive scalar, default 1).
alpha	Window size for initial blur (shock filters only, positive scalar, default 0).
sigma	Window size for diffusion tensor blur (shock filters only, positive scalar, default 0).

**Examples**

```
layout(t(1:2))
plot(boats,main="Original")
imsharpen(boats,150) %>% plot(main="Sharpened")
```

---

imshift	<i>Shift image content.</i>
---------	-----------------------------

---

**Description**

Shift image content.

**Usage**

```
imshift(
  im,
  delta_x = 0L,
  delta_y = 0L,
  delta_z = 0L,
  delta_c = 0L,
  boundary_conditions = 0L
)
```

**Arguments**

im	an image
delta_x	Amount of displacement along the X-axis.
delta_y	Amount of displacement along the Y-axis.
delta_z	Amount of displacement along the Z-axis.
delta_c	Amount of displacement along the C-axis.
boundary_conditions	can be: - 0: Zero border condition (Dirichlet). - 1: Nearest neighbors (Neumann). - 2: Repeat Pattern (Fourier style).

**Examples**

```
imshift(boats,10,50) %>% plot
```

---

```
imsplit
```

*Split an image along a certain axis (producing a list)*

---

**Description**

Use this if you need to process colour channels separately, or frames separately, or rows separately, etc. You can also use it to chop up an image into blocks. Returns an "imlist" object, which is essentially a souped-up list.

**Usage**

```
imsplit(im, axis, nb = -1)
```

**Arguments**

im	an image
axis	the axis along which to split (for example 'c')
nb	number of objects to split into. if nb=-1 (the default) the maximum number of splits is used, i.e. <code>split(im,"c")</code> produces a list containing all individual colour channels.

**See Also**

`imappend` (the reverse operation)

**Examples**

```
im <- as.cimg(function(x,y,z) x+y+z,10,10,5)
imsplit(im,"z") #Split along the z axis into a list with 5 elements
imsplit(im,"z",2) #Split along the z axis into two groups
imsplit(boats,"x",-200) %>% plot #Blocks of 200 pix. along x
imsplit(im,"z",2) %>% imappend("z") #Split and reshape into a single image
#You can also split pixsets
imsplit(boats > .5,"c") %>% plot
```

---

imsub *Select part of an image*

---

### Description

imsub selects an image part based on coordinates: it allows you to select a subset of rows, columns, frames etc. Refer to the examples to see how it works

### Usage

```
imsub(im, ...)
```

```
subim(im, ...)
```

### Arguments

im	an image
...	various conditions defining a rectangular image region

### Details

subim is an alias defined for backward-compatibility.

### Value

an image with some parts cut out

### Functions

- subim(): alias for imsub

### Author(s)

Simon Barthelme

### Examples

```
parrots <- load.example("parrots")
imsub(parrots,x < 30) #Only the first 30 columns
imsub(parrots,y < 30) #Only the first 30 rows
imsub(parrots,x < 30,y < 30) #First 30 columns and rows
imsub(parrots, sqrt(x) > 8) #Can use arbitrary expressions
imsub(parrots,x > height/2,y > width/2) #height and width are defined based on the image
#Using the %inr% operator, which is like %in% but for a numerical range
all.equal(imsub(parrots,x %inr% c(1,10)),
  imsub(parrots,x >= 1,x <= 10))
imsub(parrots,cc==1) #Colour axis is "cc" not "c" here because "c" is an important R function
##Not run
```

```
##imsub(parrots,x+y==1)
##can't have expressions involving interactions between variables (domain might not be square)
```

---

imwarp

*Image warping*


---

### Description

Image warping consists in remapping pixels, ie. you define a function  $M(x,y,z) \rightarrow (x',y',z')$  that displaces pixel content from  $(x,y,z)$  to  $(x',y',z')$ . Actual implementations rely on either the forward transformation  $M$ , or the backward (inverse) transformation  $M^{-1}$ . In CImg the forward implementation will go through all source  $(x,y,z)$  pixels and "paint" the corresponding pixel at  $(x',y',z')$ . This will result in unpainted pixels in the output if  $M$  is expansive (for example in the case of a scaling  $M(x,y,z) = 5*(x,y,z)$ ). The backward implementation will go through every pixel in the destination image and look for ancestors in the source, meaning that every pixel will be painted. There are two ways of specifying the map: absolute or relative coordinates. In absolute coordinates you specify  $M$  or  $M^{-1}$  directly. In relative coordinates you specify an offset function  $D$ :  $M(x,y) = (x,y) + D(x,y)$  (forward)  $M^{-1}(x,y) = (x,y) - D(x,y)$  (backward)

### Usage

```
imwarp(
  im,
  map,
  direction = "forward",
  coordinates = "absolute",
  boundary = "dirichlet",
  interpolation = "linear"
)
```

### Arguments

im	an image
map	a function that takes $(x,y)$ or $(x,y,z)$ as arguments and returns a named list with members $(x,y)$ or $(x,y,z)$
direction	"forward" or "backward" (default "forward")
coordinates	"absolute" or "relative" (default "relative")
boundary	boundary conditions: "dirichlet", "neumann", "periodic". Default "dirichlet"
interpolation	"nearest", "linear", "cubic" (default "linear")

### Details

Note that 3D warps are possible as well. The mapping should be specified via the "map" argument, see examples.

**Value**

a warped image

**Author(s)**

Simon Barthelme

**See Also**

warp for direct access to the CImg function

**Examples**

```
im <- load.example("parrots")
#Shift image
map.shift <- function(x,y) list(x=x+10,y=y+30)
imwarp(im,map=map.shift) %>% plot
#Shift image (backward transform)
imwarp(im,map=map.shift,dir="backward") %>% plot

#Shift using relative coordinates
map.rel <- function(x,y) list(x=10+0*x,y=30+0*y)
imwarp(im,map=map.rel,coordinates="relative") %>% plot

#Scaling
map.scaling <- function(x,y) list(x=1.5*x,y=1.5*y)
imwarp(im,map=map.scaling) %>% plot #Note the holes
map.scaling.inv <- function(x,y) list(x=x/1.5,y=y/1.5)
imwarp(im,map=map.scaling.inv,dir="backward") %>% plot #No holes

#Bending
map.bend.rel <- function(x,y) list(x=50*sin(y/10),y=0*y)
imwarp(im,map=map.bend.rel,coord="relative",dir="backward") %>% plot #No holes
```

---

im\_split

*Split an image along a certain axis (producing a list)*


---

**Description**

Split an image along a certain axis (producing a list)

**Usage**

```
im_split(im, axis, nb = -1L)
```

**Arguments**

im	an image
axis	the axis along which to split (for example 'c')
nb	number of objects to split into. if nb=-1 (the default) the maximum number of splits is used ie. split(im,"c") produces a list containing all individual colour channels

**See Also**

imappend (the reverse operation)

---

index.coord

*Linear index in internal vector from pixel coordinates*

---

**Description**

Pixels are stored linearly in (x,y,z,c) order. This function computes the vector index of a pixel given its coordinates

**Usage**

```
index.coord(im, coords, outside = "stop")
```

**Arguments**

im	an image
coords	a data.frame with values x,y,z (optional), c (optional)
outside	what to do if some coordinates are outside the image: "stop" issues error, "NA" replaces invalid coordinates with NAs. Default: "stop".

**Value**

a vector of indices (NA if the indices are invalid)

**Author(s)**

Simon Barthelme

**See Also**

coord.index, the reverse operation

**Examples**

```
im <- as.cimg(function(x,y) x+y,100,100)
px <- index.coord(im,data.frame(x=c(3,3),y=c(1,2)))
im[px] #Values should be 3+1=4, 3+2=5
```

---

inpaint	<i>Fill-in NA values in an image</i>
---------	--------------------------------------

---

**Description**

Fill in NA values (inpainting) using a Gaussian filter, i.e. replace missing pixel values with a weighted average of the neighbours.

**Usage**

```
inpaint(im, sigma)
```

**Arguments**

im	input image
sigma	std. deviation of the Gaussian (size of neighbourhood)

**Value**

an image with missing values filled-in.

**Author(s)**

Simon Barthelme

**Examples**

```
im <- boats
im[sample(nPix(im), 1e4)] <- NA
inpaint(im, 1) %>% imlist(im, .) %>%
  setNames(c("before", "after")) %>% plot(layout="row")
```

---

interact	<i>Build simple interactive interfaces using imager</i>
----------	---

---

**Description**

To explore the effect of certain image manipulations, filter settings, etc., it's useful to have a basic interaction mechanism. You can use shiny for that, but imager provides a lightweight alternative. The user writes a function that gets called every time a user event happens (a click, a keypress, etc.). The role of the function is to process the event and output an image, which will then be displayed. You can exit the interface at any time by pressing Esc. See examples for more. This feature is experimental!!! Note that you need X11 library to use this function.

**Usage**

```
interact(fun, title = "", init)
```

**Arguments**

fun	a function that takes a single argument (a list of user events) and returns an image to be plotted. The image won't be rescaled before plotting, so make sure RGB values are in [0,1].
title	a title for the window (default "", none)
init	initial image to display (optional)

**Value**

an image, specifically the last image displayed

**Author(s)**

Simon Barthelme

**Examples**

```
#Implement a basic image gallery:
#press "right" and "left" to view each image in a list
gallery <- function(iml)
{
  ind <- 1
  f <- function(state)
  {
    if (state$key=="arrowleft")
    {
      ind <-< max(ind-1,1)
    }
    if (state$key=="arrowright")
    {
      ind <-< min(ind+1,length(iml))
    }
    iml[[ind]]
  }
  interact(f)
}
##Not run (interactive only)
##map_il(1:10,~ isoblur(boats,.)) %>% gallery
```

---

interp	<i>Interpolate image values</i>
--------	---------------------------------

---

**Description**

This function provides 2D and 3D (linear or cubic) interpolation for pixel values. Locations need to be provided as a data.frame with variables x,y,z, and c (the last two are optional).

**Usage**

```
interp(im, locations, cubic = FALSE, extrapolate = TRUE)
```

**Arguments**

im	the image (class cimg)
locations	a data.frame
cubic	if TRUE, use cubic interpolation. If FALSE, use linear (default FALSE)
extrapolate	allow extrapolation (to values outside the image)

**Examples**

```
loc <- data.frame(x=runif(10,1,width(boats)),y=runif(10,1,height(boats))) #Ten random locations
interp(boats,loc)
```

---

is.cimg	<i>Checks that an object is a cimg object</i>
---------	---

---

**Description**

Checks that an object is a cimg object

**Usage**

```
is.cimg(x)
```

**Arguments**

x	an object
---	-----------

**Value**

logical

---

`is.imlist`*Check that an object is an imlist object*

---

**Description**

Check that an object is an imlist object

**Usage**

```
is.imlist(x)
```

**Arguments**

x                    an object

**Value**

logical

---

`is.pixset`*Check that an object is a pixset object*

---

**Description**

Check that an object is a pixset object

**Usage**

```
is.pixset(x)
```

**Arguments**

x                    an object

**Value**

logical

---

isoblur	<i>Blur image isotropically.</i>
---------	----------------------------------

---

**Description**

Blur image isotropically.

**Usage**

```
isoblur(im, sigma, neumann = TRUE, gaussian = TRUE, na.rm = FALSE)
```

**Arguments**

im	an image
sigma	Standard deviation of the blur (positive)
neumann	If true, use Neumann boundary conditions, Dirichlet otherwise (default true, Neumann)
gaussian	Use a Gaussian filter (actually van Vliet-Young). Default: 0th-order Deriche filter.
na.rm	if TRUE, ignore NA values. Default FALSE, in which case the whole image is NA if one of the values is NA (following the definition of the Gaussian filter)

**See Also**

deriche,vanvliet,inpaint,medianblur

**Examples**

```
isoblur(boats,3) %>% plot(main="Isotropic blur, sigma=3")
isoblur(boats,10) %>% plot(main="Isotropic blur, sigma=10")
```

---

label	<i>Label connected components.</i>
-------	------------------------------------

---

**Description**

The algorithm of connected components computation has been primarily done by A. Meijster, according to the publication: 'W.H. Hesselink, A. Meijster, C. Bron, "Concurrent Determination of Connected Components.", In: Science of Computer Programming 41 (2001), pp. 173–194'.

**Usage**

```
label(im, high_connectivity = FALSE, tolerance = 0)
```

**Arguments**

im	an image
high_connectivity	4(false)- or 8(true)-connectivity in 2d case, and between 6(false)- or 26(true)-connectivity in 3d case. Default FALSE
tolerance	Tolerance used to determine if two neighboring pixels belong to the same region.

**Examples**

```
imname <- system.file('extdata/parrots.png',package='imager')
im <- load.image(imname) %>% grayscale
#Thresholding yields different discrete regions of high intensity
regions <- isoblur(im,10) %>% threshold("97%")
labels <- label(regions)
layout(t(1:2))
plot(regions,"Regions")
plot(labels,"Labels")
```

---

lply	<i>Apply function to each element of a list, then combine the result as an image by appending along specified axis</i>
------	--

---

**Description**

This is just a shortcut for `purrr::map` followed by `imappend`

**Usage**

```
lply(lst, fun, axis, ...)
```

**Arguments**

lst	a list
fun	function to apply
axis	which axis to append along (e.g. "c" for colour)
...	further arguments to be passed to fun

**Examples**

```
build.im <- function(size) as.cimg(function(x,y) (x+y)/size,size,size)
lply(c(10,50,100),build.im,"y") %>% plot
```

---

load.dir	<i>Load all images in a directory</i>
----------	---------------------------------------

---

**Description**

Load all images in a directory and return them as an image list.

**Usage**

```
load.dir(path, pattern = NULL, quiet = FALSE)
```

**Arguments**

path	directory to load from
pattern	optional: file pattern (ex. *.jpg). Default NULL, in which case we look for file extensions png,jpeg,jpg,tif,bmp.
quiet	if TRUE, loading errors are quiet. If FALSE, they are displayed. Default FALSE

**Value**

an image list

**Author(s)**

Simon Barthelme

**Examples**

```
path <- system.file(package="imager") %>% paste0("/extdata")
load.dir(path)
```

---

load.example	<i>Load example image</i>
--------------	---------------------------

---

**Description**

Imager ships with five test pictures and a video. Two (parrots and boats) come from the [Kodak set](<http://r0k.us/graphics/kodak/>). Another (birds) is a sketch of birds by Leonardo, from Wikimedia. The "coins" image comes from scikit-image. The Hubble Deep field (hubble) is from Wikimedia. The test video ("tennis") comes from [xiph.org](<https://media.xiph.org/video/derf/>)'s collection.

**Usage**

```
load.example(name)
```

**Arguments**

name            name of the example

**Value**

an image

**Author(s)**

Simon Barthelme

**Examples**

```
load.example("hubble") %>% plot
load.example("birds") %>% plot
load.example("parrots") %>% plot
```

---

load.image	<i>Load image from file or URL</i>
------------	------------------------------------

---

**Description**

PNG, JPEG and BMP are supported via the readbitmap package. You'll need to install ImageMagick for other formats. If the path is actually a URL, it should start with http(s) or ftp(s).

**Usage**

```
load.image(file)
```

**Arguments**

file            path to file or URL

**Value**

an object of class 'cimg'

**Examples**

```
#Find path to example file from package
fpath <- system.file('extdata/Leonardo_Birds.jpg', package='imager')
im <- load.image(fpath)
plot(im)
#Load the R logo directly from the CRAN webpage
#load.image("https://cran.r-project.org/Rlogo.jpg") %>% plot
```

---

load.video	<i>Load a video using ffmpeg</i>
------------	----------------------------------

---

### Description

You need to have ffmpeg on your path for this to work. This function uses ffmpeg to split the video into individual frames, which are then loaded as images and recombined. Videos are memory-intensive, and load.video performs a safety check before loading a video that would be larger than maxSize in memory (default 1GB)

### Usage

```
load.video(  
  fname,  
  maxSize = 1,  
  skip.to = 0,  
  frames = NULL,  
  fps = NULL,  
  extra.args = "",  
  verbose = FALSE  
)
```

### Arguments

fname	file to load
maxSize	max. allowed size in memory, in GB (default max 1GB).
skip.to	skip to a certain point in time (in sec., or "hh:mm:ss" format)
frames	number of frames to load (default NULL, all)
fps	frames per second (default NULL, determined automatically)
extra.args	extra arguments to be passed to ffmpeg (default "", none)
verbose	if TRUE, show ffmpeg output (default FALSE)

### Value

an image with the extracted frames along the "z" coordinates

### Author(s)

Simon Barthelme

### See Also

save.video, make.video

## Examples

```
fname <- system.file('extdata/tennis_sif.mpeg',package='imager')
##Not run
## load.video(fname) %>% play
## load.video(fname,fps=10) %>% play
## load.video(fname,skip=2) %>% play
```

---

magick

*Convert a magick image to a cimg image or image list and vice versa*

---

## Description

The magick library package stores its data as "magick-image" object, which may in fact contain several images or an animation. These functions convert magick objects into imager objects or imager objects into magick objects. Note that cimg2magick function requires magick package.

## Usage

```
magick2imlist(obj, alpha = "rm", ...)
```

```
magick2cimg(obj, alpha = "rm", ...)
```

```
cimg2magick(im, rotate = TRUE)
```

## Arguments

obj	an object of class "magick-image"
alpha	what do to with the alpha channel ("rm": remove and store as attribute, "flatten": flatten, "keep": keep). Default: "rm"
...	ignored
im	an image of class cimg
rotate	determine if rotate image to adjust orientation of image

## Value

an object of class cimg or imlist  
an object of class "magick-image"

## Author(s)

Jan Wijffels, Simon Barthelme  
Shota Ochi

## See Also

flatten.alpha, rm.alpha

---

`make.video`*Make/save a video using ffmpeg*

---

### Description

You need to have ffmpeg on your path for this to work. This function uses ffmpeg to combine individual frames into a video. `save.video` can be called directly with an image or image list as input. `make.video` takes as argument a directory that contains a sequence of images representing individual frames to be combined into a video.

### Usage

```
make.video(  
    dname,  
    fname,  
    pattern = "image-%d.png",  
    fps = 25,  
    extra.args = "",  
    verbose = FALSE  
)  
  
save.video(im, fname, ...)
```

### Arguments

<code>dname</code>	name of a directory containing individual files
<code>fname</code>	name of the output file. The format is determined automatically from the name (example "a.mpeg" will have MPEG format)
<code>pattern</code>	pattern of filename for frames (the default matches "image-1.png", "image-2.png", etc.. See ffmpeg documentation for more).
<code>fps</code>	frames per second (default 25)
<code>extra.args</code>	extra arguments to be passed to ffmpeg (default "", none)
<code>verbose</code>	if TRUE, show ffmpeg output (default FALSE)
<code>im</code>	an image or image list
<code>...</code>	extra arguments to <code>save.video</code> , passed on to <code>make.video</code>

### Functions

- `save.video()`: Save a video using ffmpeg

### Author(s)

Simon Barthelme

**See Also**

load.video

**Examples**

```
## Not run
## iml <- map_il(seq(0,20,l=60),~ isoblur(boats,.))
## f <- tempfile(fileext=".avi")
## save.video(iml,f)
## load.video(f) %>% play
## #Making a video from a directory
## dd <- tempdir()
## for (i in 1:length(iml)) {
##   png(sprintf("%s/image-%i.png",dd,i));
##   plot(iml[[i]]); dev.off() }
## make.video(dd,f)
## load.video(f) %>% play
```

---

map\_il

*Type-stable map for use with the purrr package*

---

**Description**

Works like `purrr::map`, `purrr::map_dbl` and the like but ensures that the output is an image list.

**Usage**

`map_il(...)`

`map2_il(...)`

`pmap_il(...)`

**Arguments**

`...` passed to `map`

**Value**

an image list

**Functions**

- `map2_il()`: Parallel map (two values)
- `pmap_il()`: Parallel map (multiple values)

**Author(s)**

Simon Barthelme

**Examples**

```
#Returns a list
imsplit(boats,"x",2) %>% purrr::map(~ isoblur(.,3))
#Returns an "imlist" object
imsplit(boats,"x",2) %>% map_il(~ isoblur(.,3))
#Fails if function returns an object that's not an image
try(imsplit(boats,"x",2) %>% map_il(~ . > 2))
#Parallel maps
map2_il(1:3,101:103,~ imshift(boats,.,.y))
pmap_il(list(x=1:3,y=4:6,z=7:9),function(x,y,z) imfill(x,y,z))
```

---

medianblur	<i>Blur image with the median filter. In a window of size <math>n \times n</math> centered at pixel <math>(x,y)</math>, compute median pixel value over the window. Optionally, ignore values that are too far from the value at current pixel.</i>
------------	---

---

**Description**

Blur image with the median filter.

In a window of size  $n \times n$  centered at pixel  $(x,y)$ , compute median pixel value over the window. Optionally, ignore values that are too far from the value at current pixel.

**Usage**

```
medianblur(im, n, threshold = 0)
```

**Arguments**

im	an image
n	Size of the median filter.
threshold	Threshold used to discard pixels too far from the current pixel value in the median computation. Can be used for edge-preserving smoothing. Default 0 (include all pixels in window).

**See Also**

isoblur, boxblur

**Examples**

```
medianblur(boats,5) %>% plot(main="Median blur, 5 pixels")
medianblur(boats,10) %>% plot(main="Median blur, 10 pixels")
medianblur(boats,10,8) %>% plot(main="Median blur, 10 pixels, threshold = 8")
```

---

mirror	<i>Mirror image content along specified axis</i>
--------	--

---

**Description**

Mirror image content along specified axis

**Usage**

```
mirror(im, axis)
```

**Arguments**

im	an image
axis	Mirror axis ("x","y","z","c")

**Examples**

```
mirror(boats,"x") %>% plot  
mirror(boats,"y") %>% plot
```

---

mutate_plyr	<i>Mutate a data frame by adding new or replacing existing columns.</i>
-------------	---

---

**Description**

This function copied directly from plyr, and modified to use a different name to avoid namespace collisions with dplyr/tidyverse functions.

**Usage**

```
mutate_plyr(.data, ...)
```

**Arguments**

.data	the data frame to transform
...	named parameters giving definitions of new columns.

**Details**

This function is very similar to [transform](#) but it executes the transformations iteratively so that later transformations can use the columns created by earlier transformations. Like transform, unnamed components are silently dropped.

Mutate seems to be considerably faster than transform for large data frames.

---

nflines	<i>Plot a line, Hesse normal form parameterisation</i>
---------	--

---

### Description

This is a simple interface over `abline` meant to be used along with the Hough transform. In the Hesse normal form  $(\theta, \rho)$ , a line is represented as the set of values  $(x, y)$  such that  $\cos(\theta) * x + \sin(\theta) * y = \rho$ . Here  $\theta$  is an angle and  $\rho$  is a distance. See the documentation for `hough_lines`.

### Usage

```
nflines(theta, rho, col, ...)
```

### Arguments

<code>theta</code>	angle (radians)
<code>rho</code>	distance
<code>col</code>	colour
<code>...</code>	other graphical parameters, passed along to <code>abline</code>

### Value

nothing

### Author(s)

Simon Barthelme

### Examples

```
#Boring example, see ?hough_lines
plot(boats)
nflines(theta=0, rho=10, col="red")
```

---

pad	<i>Pad image with n pixels along specified axis</i>
-----	---

---

### Description

Pad image with n pixels along specified axis

### Usage

```
pad(im, nPix, axes, pos = 0, val)
```

### Arguments

im	the input image
nPix	how many pixels to pad with
axes	which axes to pad along
pos	-1: prepend 0; center 1: append
val	colour of the padded pixels (default 0 in all channels). Can be a string for colour images, e.g. "red", or "black".

### Value

a padded image

### Author(s)

Simon Barthelme

### Examples

```
pad(boats,20,"xy") %>% plot
pad(boats,20,pos=-1,"xy") %>% plot
pad(boats,20,pos=1,"xy") %>% plot
pad(boats,20,pos=1,"xy",val="red") %>% plot
```

---

patchstat	<i>Return image patch summary</i>
-----------	-----------------------------------

---

### Description

Patches are rectangular image regions centered at  $cx, cy$  with width  $wx$  and height  $wy$ . This function provides a fast way of extracting a statistic over image patches (for example, their mean). Supported functions: `sum`, `mean`, `min`, `max`, `median`, `var`, `sd`, or any valid `CImg` expression. **WARNINGS:** - values outside of the image region are considered to be 0. - widths and heights should be odd integers (they're rounded up otherwise).

### Usage

```
patchstat(im, expr, cx, cy, wx, wy)
```

### Arguments

<code>im</code>	an image
<code>expr</code>	statistic to extract. a string, either one of the usual statistics like "mean", "median", or a <code>CImg</code> expression.
<code>cx</code>	vector of x coordinates for patch centers
<code>cy</code>	vector of y coordinates for patch centers
<code>wx</code>	vector of patch widths (or single value)
<code>wy</code>	vector of patch heights (or single value)

### Value

a numeric vector

### See Also

`extract_patches`

### Examples

```
im <- grayscale(boats)
#Mean of an image patch centered at (10,10) of size 3x3
patchstat(im, 'mean', 10, 10, 3, 3)
#Mean of image patches centered at (10,10) and (20,4) of size 2x2
patchstat(im, 'mean', c(10, 20), c(10, 4), 5, 5)
#Sample 10 random positions
ptch <- pixel.grid(im) %>% dplyr::sample_n(10)
#Compute median patch value
with(ptch, patchstat(im, 'median', x, y, 3, 3))
```

---

patch_summary_cimg	<i>Extract a numerical summary from image patches, using CImg's mini-language Experimental feature.</i>
--------------------	---

---

### Description

Extract a numerical summary from image patches, using CImg's mini-language Experimental feature.

### Usage

```
patch_summary_cimg(im, expr, cx, cy, wx, wy)
```

### Arguments

im	an image
expr	a CImg expression (as a string)
cx	vector of x coordinates for patch centers
cy	vector of y coordinates for patch centers
wx	vector of coordinates for patch width
wy	vector of coordinates for patch height

### Examples

```
#Example: median filtering using patch_summary_cimg
#Center a patch at each pixel
im <- grayscale(boats)
patches <- pixel.grid(im) %>% dplyr::mutate(w=3,h=3)
#Extract patch summary
out <- dplyr::mutate(patches,med=patch_summary_cimg(im,"ic",x,y,w,h))
as.cimg(out,v.name="med") %>% plot
```

---

periodic.part	<i>Compute the periodic part of an image, using the periodic/smooth decomposition of Moisan (2011)</i>
---------------	--

---

### Description

Moisan (2011) defines an additive image decomposition  $im = \text{periodic} + \text{smooth}$  where the periodic part shouldn't be too far from the original image. The periodic part can be used in frequency-domain analyses, to reduce the artifacts induced by non-periodicity.

**Usage**

```
periodic.part(im)
```

**Arguments**

im                    an image

**Value**

an image

**Author(s)**

Simon Barthelme

**References**

L. Moisan, Periodic plus Smooth Image Decomposition, J. Math. Imaging Vision, vol. 39:2, pp. 161-179, 2011

**Examples**

```
im <- load.example("parrots") %>% subim(x <= 512)
layout(t(1:3))
plot(im, main="Original image")
periodic.part(im) %>% plot(main="Periodic part")
#The smooth error is the difference between
#the original image and its periodic part
(im-periodic.part(im)) %>% plot(main="Smooth part")
```

---

permute\_axes

*Permute image axes*

---

**Description**

By default images are stored in xyzc order. Use permute\_axes to change that order.

**Usage**

```
permute_axes(im, perm)
```

**Arguments**

im                    an image  
 perm                  a character string, e.g., "zyc" to have the z-axis come first

**Examples**

```
im <- array(0,c(10,30,40,3)) %>% as.cimg
permute_axes(im,"zxyz")
```

---

pixel.grid

*Return the pixel grid for an image*

---

**Description**

The pixel grid for image `im` gives the (x,y,z,c) coordinates of each successive pixel as a data.frame. The c coordinate has been renamed 'cc' to avoid conflicts with R's c function. NB: coordinates start at (x=1,y=1), corresponding to the top left corner of the image, unless `standardise == TRUE`, in which case we use the usual Cartesian coordinates with origin at the center of the image and scaled such that x varies between -0.5 and 0.5, and a y arrow pointing up

**Usage**

```
pixel.grid(im, standardise = FALSE, drop.unused = TRUE, dim = NULL)
```

**Arguments**

<code>im</code>	an image
<code>standardise</code>	If TRUE use a centered, scaled coordinate system. If FALSE use standard image coordinates (default FALSE)
<code>drop.unused</code>	if TRUE ignore empty dimensions, if FALSE include them anyway (default TRUE)
<code>dim</code>	a vector of image dimensions (optional, may be used instead of "im")

**Value**

a data.frame

**Examples**

```
im <- as.cimg(array(0,c(10,10))) #A 10x10 image
pixel.grid(im) %>% head
pixel.grid(dim=dim(im)) %>% head #Same as above
pixel.grid(dim=c(10,10,3,2)) %>% head
pixel.grid(im,standardise=TRUE) %>% head
pixel.grid(im,drop.unused=FALSE) %>% head
```

---

pixset	<i>Pixel sets (pixsets)</i>
--------	-----------------------------

---

**Description**

Pixel sets represent sets of pixels in images (ROIs, foreground, etc.). From an implementation point of view, they're just a thin layer over arrays of logical values, just like the `cimg` class is a layer over arrays of numeric values. Pixsets can be turned back into logical arrays, but they come with a number of generic functions that should make your life easier. They are created automatically whenever you run a test on an image (for example `im > 0` returns a pixset).

**Usage**

```
pixset(x)
```

**Arguments**

x	an array of logical values
---	----------------------------

**Examples**

```
#A test on an image returns a pixset
boats > 250
#Pixsets can be combined using the usual Boolean operators
(boats > 230) & (Xc(boats) < width(boats)/2)
#Subset an image using a pixset
boats[boats > 250]
#Turn a pixset into an image
as.cimg(boats > 250)
#Equivalently:
(boats > 250) + 0
```

---

play	<i>Play a video</i>
------	---------------------

---

**Description**

A very basic video player. Press the space bar to pause and ESC to close. Note that you need X11 library to use this function.

**Usage**

```
play(vid, loop = FALSE, delay = 30L, normalise = TRUE)
```

**Arguments**

vid	A cimg object, to be played as video
loop	loop the video (default false)
delay	delay between frames, in ms. Default 30.
normalise	if true pixel values are rescaled to 0...255 (default TRUE). The normalisation is based on the <i>*first frame*</i> . If you don't want the default behaviour you can normalise by hand. Default TRUE.

---

plot.cimg

---

*Display an image using base graphics*


---

**Description**

If you want to control precisely how numerical values are turned into colours for plotting, you need to specify a colour scale using the `colourscale` argument (see examples). Otherwise the default is "gray" for grayscale images, "rgb" for colour. These expect values in [0..1], so the default is to rescale the data to [0..1]. If you wish to over-ride that behaviour, set `rescale=FALSE`. See examples for an explanation. If the image is one dimensional (i.e., a simple row or column image), then pixel values will be plotted as a line.

**Usage**

```
## S3 method for class 'cimg'
plot(
  x,
  frame,
  xlim = c(1, width(x)),
  ylim = c(height(x), 1),
  xlab = "x",
  ylab = "y",
  rescale = TRUE,
  colourscale = NULL,
  colorscale = NULL,
  interpolate = TRUE,
  axes = TRUE,
  main = "",
  xaxs = "i",
  yaxs = "i",
  asp = 1,
  col.na = rgb(0, 0, 0, 0),
  ...
)
```

**Arguments**

x	the image
frame	which frame to display, if the image has depth > 1
xlim	x plot limits (default: 1 to width)
ylim	y plot limits (default: 1 to height)
xlab	x axis label
ylab	y axis label
rescale	rescale pixel values so that their range is [0,1]
colourscale, colorscale	an optional colour scale (default is gray or rgb)
interpolate	should the image be plotted with antialiasing (default TRUE)
axes	Whether to draw axes (default TRUE)
main	Main title
xaxs	The style of axis interval calculation to be used for the x-axis. See ?par
yaxs	The style of axis interval calculation to be used for the y-axis. See ?par
asp	aspect ratio. The default value (1) means that the aspect ratio of the image will be kept regardless of the dimensions of the plot. A numeric value other than one changes the aspect ratio, but it will be kept the same regardless of dimensions. Setting asp="varying" means the aspect ratio will depend on plot dimensions (this used to be the default in versions of imager < 0.40)
col.na	which colour to use for NA values, as R rgb code. The default is "rgb(0,0,0,0)", which corresponds to a fully transparent colour.
...	other parameters to be passed to plot.default (eg "main")

**See Also**

display, which is much faster, as.raster, which converts images to R raster objects

**Examples**

```
plot(boats,main="Boats")
plot(boats,axes=FALSE,xlab="",ylab="")

#Pixel values are rescaled to 0-1 by default, so that the following two plots are identical
plot(boats)
plot(boats/255,main="Rescaled")
#If you don't want that behaviour, you can set rescale to FALSE, but
#then you need to make sure values are in [0,1]
try(plot(boats,rescale=FALSE)) #Error!
try(plot(boats/255,rescale=FALSE)) #Works
#You can specify a colour scale if you don't want the default one.
#A colour scale is a function that takes pixels values and return an RGB code,
#like R's rgb function,e.g.
rgb(0,1,0)
```

```

#Let's switch colour channels
cscale <- function(r,g,b) rgb(b,g,r)
plot(boats/255,rescale=FALSE,colourscale=cscale)
#Display slice of HSV colour space
im <- imfill(255,255,val=1)
im <- list(Xc(im)/255,Yc(im)/255,im) %>% imappend("c")
plot(im,colourscale=hsv,rescale=FALSE,
      xlab="Hue",ylab="Saturation")
#In grayscale images, the colourscale function should take in a single value
#and return an RGB code
boats.gs <- grayscale(boats)
#We use an interpolation function from package scales
cscale <- scales::gradient_n_pal(c("red","purple","lightblue"),c(0,.5,1))
plot(boats.gs,rescale=FALSE,colourscale=cscale)
#Plot a one-dimensional image
imsub(boats,x==1) %>% plot(main="Image values along first column")
#Plotting with and without anti-aliasing:
boats.small <- imresize(boats,.3)
plot(boats.small,interp=TRUE)
plot(boats.small,interp=FALSE)

```

---

plot.imlist

*Plot an image list*


---

## Description

Each image in the list will be plotted separately. The layout argument controls the overall layout of the plot window. The default layout is "rect", which will fit all of your images into a rectangle that's as close to a square as possible.

## Usage

```

## S3 method for class 'imlist'
plot(x, layout = "rect", ...)

```

## Arguments

x	an image list (of type imlist)
layout	either a matrix (in the format defined by the layout command) or one of "row", "col" or "rect". Default: "rect"
...	other parameters, to be passed to the plot command

## Author(s)

Simon Barthelme

**Examples**

```

imsplit(boats,"c") #Returns an image list
imsplit(boats,"c") %>% plot
imsplit(boats,"c") %>% plot(layout="row")
imsplit(boats,"c") %>% plot(layout="col")
imsplit(boats,"x",5) %>% plot(layout="rect")

```

---

px.flood

*Select a region of homogeneous colour*


---

**Description**

Select pixels that are similar to a seed pixel. The underlying algorithm is the same as the bucket fill (AKA flood fill). Unlike with the bucket fill, the image isn't changed, the function simply returns a pixel set containing the selected pixels.

**Usage**

```
px.flood(im, x, y, z = 1, sigma = 0, high_connexity = FALSE)
```

**Arguments**

im	an image
x	X-coordinate of the starting point of the region to flood
y	Y-coordinate of the starting point of the region to flood
z	Z-coordinate of the starting point of the region to flood
sigma	Tolerance concerning neighborhood values.
high_connexity	Use 8-connexity (only for 2d images, default FALSE).

**Details**

Old name: selectSimilar (deprecated)

**See Also**

bucketfill

**Examples**

```

#Select part of a sail
px <- px.flood(boats,x=169,y=179,sigma=.2)
plot(boats)
highlight(px)

```

---

px.na	<i>A pixset for NA values</i>
-------	-------------------------------

---

**Description**

A pixset containing all NA pixels

**Usage**

```
px.na(im)
```

**Arguments**

im                    an image

**Value**

a pixset

**Examples**

```
im <- boats
im[1] <- NA
px.na(im)
```

---

px.remove_outer	<i>Remove all connected regions that touch image boundaries</i>
-----------------	---

---

**Description**

All pixels that belong to a connected region in contact with image boundaries are set to FALSE.

**Usage**

```
px.remove_outer(px)
```

**Arguments**

px                    a pixset

**Value**

a pixset

**Author(s)**

Simon Barthelme

**Examples**

```
im <- draw_circle(imfill(100,100),c(0,50,100),c(50,50,50),radius=10,color=1)
plot(im)
as.pixset(im) %>% px.remove_outer %>% plot
```

---

RasterPackage

*Convert a RasterLayer/RasterBrick to a cimg image/image list*

---

**Description**

The raster library stores its data as "RasterLayer" and "RasterBrick" objects. The raster package can store its data out-of-RAM, so in order not to load too much data the "maxpixels" argument sets a limit on how many pixels are loaded.

**Usage**

```
## S3 method for class 'RasterLayer'
as.cimg(obj, maxpixels = 1e+07, ...)

## S3 method for class 'RasterStackBrick'
as.imlist(obj, maxpixels = 1e+07, ...)
```

**Arguments**

obj	an object of class "RasterLayer"
maxpixels	max. number of pixels to load (default 1e7)
...	ignored

**Author(s)**

Simon Barthelme, adapted from the image method for RasterLayer by Robert J Hijmans

---

renorm	<i>Renormalise image</i>
--------	--------------------------

---

**Description**

Pixel data is usually expressed on a 0...255 scale for displaying. This function performs a linear renormalisation to range min...max

**Usage**

```
renorm(x, min = 0, max = 255)
```

**Arguments**

x	numeric data
min	min of the range
max	max of the range

**Author(s)**

Simon Barthelme

**Examples**

```
renorm(0:10)
renorm(-5:5) #Same as above
```

---

resize	<i>Resize image</i>
--------	---------------------

---

**Description**

If the dimension arguments are negative, they are interpreted as a proportion of the original image.

**Usage**

```
resize(
  im,
  size_x = -100L,
  size_y = -100L,
  size_z = -100L,
  size_c = -100L,
  interpolation_type = 1L,
  boundary_conditions = 0L,
```

```

    centering_x = 0,
    centering_y = 0,
    centering_z = 0,
    centering_c = 0
)

```

### Arguments

<code>im</code>	an image
<code>size_x</code>	Number of columns (new size along the X-axis).
<code>size_y</code>	Number of rows (new size along the Y-axis).
<code>size_z</code>	Number of slices (new size along the Z-axis).
<code>size_c</code>	Number of vector-channels (new size along the C-axis).
<code>interpolation_type</code>	Method of interpolation: -1 = no interpolation: raw memory resizing. 0 = no interpolation: additional space is filled according to <code>boundary_conditions</code> . 1 = nearest-neighbor interpolation. 2 = moving average interpolation. 3 = linear interpolation. 4 = grid interpolation. 5 = cubic interpolation. 6 = lanczos interpolation.
<code>boundary_conditions</code>	Border condition type.
<code>centering_x</code>	Set centering type (only if <code>interpolation_type=0</code> ).
<code>centering_y</code>	Set centering type (only if <code>interpolation_type=0</code> ).
<code>centering_z</code>	Set centering type (only if <code>interpolation_type=0</code> ).
<code>centering_c</code>	Set centering type (only if <code>interpolation_type=0</code> ).

### See Also

See `imresize` for an easier interface.

---

<code>resize_doubleXY</code>	<i>Resize image uniformly</i>
------------------------------	-------------------------------

---

### Description

Resize image by a single scale factor. For non-uniform scaling and a wider range of options, see `resize`.

### Usage

```

resize_doubleXY(im)

resize_halfXY(im)

resize_tripleXY(im)

imresize(im, scale = 1, interpolation = 3)

```

**Arguments**

im	an image
scale	a scale factor
interpolation	interpolation method to use (see doc for resize). Default 3, linear. Set to 5 for cubic, 6 for Lanczos (higher quality).

**Value**

an image

**Functions**

- `resize_doubleXY()`: Double size
- `resize_halfXY()`: Half size
- `resize_tripleXY()`: Triple size
- `imresize()`: resize by scale factor

**Author(s)**

Simon Barthelme

**References**

For double-scale, triple-scale, etc. uses an anisotropic scaling algorithm described in: <http://www.scale2x.it/algorithm.html>. For half-scaling uses what the CImg doc describes as an "optimised filter", see `resize_halfXY` in CImg.h.

**See Also**

`resize`

**Examples**

```
im <- load.example("parrots")
imresize(im,1/4) #Quarter size
map_il(2:4,~ imresize(im,1/.)) %>% imappend("x") %>% plot
```

**Description**

All functions listed here assume the input image has three colour channels (`spectrum(im) == 3`)

**Usage**

RGBtoHSL(im)

RGBtoXYZ(im)

XYZtoRGB(im)

HSLtoRGB(im)

RGBtoHSV(im)

HSVtoRGB(im)

RGBtoHSI(im)

HSItoRGB(im)

RGBtosRGB(im)

sRGBtoRGB(im)

RGBtoYCbCr(im)

YCbCrtoRGB(im)

RGBtoYUV(im)

YUVtoRGB(im)

LabtoRGB(im)

RGBtoLab(im)

LabtoXYZ(im)

XYZtoLab(im)

LabtosRGB(im)

sRGBtoLab(im)

### Arguments

im                    an image

### Functions

- RGBtoHSL(): RGB to HSL conversion
- RGBtoXYZ(): CIE RGB to CIE XYZ (1931) conversion, D65 white point
- XYZtoRGB(): CIE XYZ to CIE RGB (1931) conversion, D65 white point
- HSLtoRGB(): HSL to RGB conversion
- RGBtoHSV(): RGB to HSV conversion
- HSVtoRGB(): HSV to RGB conversion
- RGBtoHSI(): RGB to HSI conversion
- HSItoRGB(): HSI to RGB conversion
- RGBtosRGB(): RGB to sRGB conversion
- sRGBtoRGB(): sRGB to RGB conversion
- RGBtoYCbCr(): RGB to YCbCr conversion
- YCbCrtoRGB(): YCbCr to RGB conversion
- RGBtoYUV(): RGB to YUV conversion
- YUVtoRGB(): YUV to RGB conversion
- LabtoRGB(): Lab to RGB (linear)
- RGBtoLab(): RGB (linear) to Lab
- LabtoXYZ(): Lab to XYZ
- XYZtoLab(): XYZ to Lab
- LabtosRGB(): Lab to sRGB
- sRGBtoLab(): sRGB to Lab

---

rm.alpha

*Remove alpha channel and store as attribute*

---

### Description

Remove alpha channel and store as attribute

### Usage

rm.alpha(im)

### Arguments

im                    an image with 4 RGBA colour channels

**Value**

an image with only three RGB channels and the alpha channel as attribute

**Author(s)**

Simon Barthelme

**See Also**

flatten.alpha

**Examples**

```
#An image with 4 colour channels (RGBA)
im <- imfill(2,2,val=c(0,0,0,0))
#Remove fourth channel
rm.alpha(im)
attr(rm.alpha(im),"alpha")
```

---

rotate\_xy

*Rotate image by an arbitrary angle, around a center point.*

---

**Description**

Rotate image by an arbitrary angle, around a center point.

**Usage**

```
rotate_xy(im, angle, cx, cy, interpolation = 1L, boundary_conditions = 0L)
```

**Arguments**

im	an image
angle	Rotation angle, in degrees.
cx	X-coordinate of the rotation center.
cy	Y-coordinate of the rotation center.
interpolation	Interpolation type. 0=nearest   1=linear   2=cubic
boundary_conditions	Boundary conditions. 0=dirichlet   1=neumann   2=periodic

**Examples**

```
rotate_xy(boats,30,200,400) %>% plot
rotate_xy(boats,30,200,400,boundary=2) %>% plot
```

---

save.image	<i>Save image</i>
------------	-------------------

---

**Description**

You'll need ImageMagick for formats other than PNG and JPEG.

**Usage**

```
save.image(im, file, quality = 0.7)
```

**Arguments**

im	an image (of class cimg)
file	path to file. The format is determined by the file's name
quality	(JPEG only) default 0.7. Higher quality means less compression.

**Value**

nothing

**See Also**

save.video

**Examples**

```
#Create temporary file
tmpF <- tempfile(fileext=".png")
#Save boats image
save.image(boats,tmpF)
#Read back and display
load.image(tmpF) %>% plot
```

---

split_connected	<i>Split pixset into connected components</i>
-----------------	---

---

**Description**

Compute connected components (using "label"), then split into as many sets as there are components. Useful for segmentation

**Usage**

```
split_connected(px, ...)
```

**Arguments**

px                    a pixset  
...                    further arguments passed to label

**Value**

a list of pixsets

**Author(s)**

Simon Barthelme

**See Also**

label

**Examples**

```
px <- isoblur(grayscale(boats),5) > .75
plot(px)
spl <- split_connected(px)
plot(spl[[1]])
px <- isoblur(grayscale(boats),5) > .75
plot(px)
spl <- split_connected(px)
plot(spl[[1]])
```

---

squeeze

*Remove empty dimensions from an array*

---

**Description**

Works just like Matlab's squeeze function: if anything in `dim(x)` equals one the corresponding dimension is removed

**Usage**

```
squeeze(x)
```

**Arguments**

x                    an array

**Examples**

```
A <- array(1:9,c(3,1,3)) #3D array with one flat dimension
A %>% squeeze #flat dimension removed
```

---

stencil.cross	<i>A cross-shaped stencil</i>
---------------	-------------------------------

---

**Description**

Returns a stencil corresponding to all nearest-neighbours of a pixel

**Usage**

```
stencil.cross(z = FALSE, cc = FALSE, origin = FALSE)
```

**Arguments**

z	include neighbours along the z axis
cc	include neighbours along the cc axis
origin	include center pixel (default false)

**Value**

a data.frame defining a stencil

**Author(s)**

Simon Barthelme

**See Also**

get.stencil

---

threshold	<i>Threshold grayscale image</i>
-----------	----------------------------------

---

**Description**

Thresholding corresponding to setting all values below a threshold to 0, all above to 1. If you call threshold with thr="auto" a threshold will be computed automatically using kmeans (ie., using a variant of Otsu's method). This works well if the pixel values have a clear bimodal distribution. If you call threshold with a string argument of the form "XX%" (e.g., "98%"), the threshold will be set at percentile XX. Computing quantiles or running kmeans is expensive for large images, so if approx == TRUE threshold will skip pixels if the total number of pixels is above 10,000. Note that thresholding a colour image will threshold all the colour channels jointly, which may not be the desired behaviour! Use iiply(im,"c",threshold) to find optimal values for each channel separately.

**Usage**

```
threshold(im, thr = "auto", approx = TRUE, adjust = 1)
```

**Arguments**

im	the image
thr	a threshold, either numeric, or "auto", or a string for quantiles
approx	Skip pixels when computing quantiles in large images (default TRUE)
adjust	use to adjust the automatic threshold: if the auto-threshold is at k, effective threshold will be at adjust*k (default 1)

**Value**

a pixset with the selected pixels

**Author(s)**

Simon Barthelme

**Examples**

```
im <- load.example("birds")
im.g <- grayscale(im)
threshold(im.g,"15%") %>% plot
threshold(im.g,"auto") %>% plot
threshold(im.g,.1) %>% plot
#If auto-threshold is too high, adjust downwards or upwards
#using "adjust"
threshold(im,adjust=.5) %>% plot
threshold(im,adjust=1.3) %>% plot
```

---

vanvliet

*Young-Van Vliet recursive Gaussian filter.*

---

**Description**

The Young-van Vliet filter is a fast approximation to a Gaussian filter (order = 0), or Gaussian derivatives (order = 1 or 2).

**Usage**

```
vanvliet(im, sigma, order = 0L, axis = "x", neumann = FALSE)
```

**Arguments**

im	an image
sigma	standard deviation of the Gaussian filter
order	the order of the filter 0,1,2,3
axis	Axis along which the filter is computed. One of 'x', 'y', 'z', 'c'
neumann	If true, use Neumann boundary conditions (default false, Dirichlet)

## References

From: I.T. Young, L.J. van Vliet, M. van Ginkel, Recursive Gabor filtering. IEEE Trans. Sig. Proc., vol. 50, pp. 2799-2805, 2002. (this is an improvement over Young-Van Vliet, Sig. Proc. 44, 1995)

Boundary conditions (only for order 0) using Triggs matrix, from B. Triggs and M. Sdika. Boundary conditions for Young-van Vliet recursive filtering. IEEE Trans. Signal Processing, vol. 54, pp. 2365-2367, 2006.

## Examples

```
vanvliet(boats,sigma=2,order=0) %>% plot("Zeroth-order Young-van Vliet along x")
vanvliet(boats,sigma=2,order=1) %>% plot("First-order Young-van Vliet along x")
vanvliet(boats,sigma=2,order=1) %>% plot("Second-order Young-van Vliet along x")
vanvliet(boats,sigma=2,order=1,axis="y") %>% plot("Second-order Young-van Vliet along y")
```

---

warp

*Warp image*

---

## Description

Warp image

## Usage

```
warp(im, warpfield, mode = 0L, interpolation = 1L, boundary_conditions = 0L)
```

## Arguments

im	an image
warpfield	Warping field. The (x,y,z) fields should be stacked along the colour coordinate.
mode	Can be 0=backward-absolute   1=backward-relative   2=forward-absolute   3=forward-relative
interpolation	Can be <tt> 0=nearest   1=linear   2=cubic </tt>.
boundary_conditions	Boundary conditions. Can be <tt> 0=dirichlet   1=neumann   2=periodic </tt>.

## See Also

imwarp for a user-friendly interface

## Examples

```
#Shift image via warp
warp.x <- imfill(width(boats),height(boats),val=5)
warp.y <- imfill(width(boats),height(boats),val=20)
warpfield <- list(warp.x,warp.y) %>% imappend("c")
warp(boats,warpfield,mode=1) %>% plot
```

---

watershed	<i>Compute watershed transform.</i>
-----------	-------------------------------------

---

### Description

The watershed transform is a label propagation algorithm. The value of non-zero pixels will get propagated to their zero-value neighbours. The propagation is controlled by a priority map. See examples.

### Usage

```
watershed(im, priority, fill_lines = TRUE)
```

### Arguments

<code>im</code>	an image
<code>priority</code>	Priority map.
<code>fill_lines</code>	Sets if watershed lines must be filled or not.

### Examples

```
#In our initial image we'll place three seeds
#(non-zero pixels) at various locations, with values 1, 2 and 3.
#We'll use the watershed algorithm to propagate these values
imd <- function(x,y) imdirac(c(100,100,1,1),x,y)
im <- imd(20,20)+2*imd(40,40)+3*imd(80,80)
layout(t(1:3))
plot(im,main="Seed image")
#Now we build an priority map: neighbours of our seeds
#should get high priority.
#We'll use a distance map for that
p <- 1-distance_transform(sign(im),1)
plot(p,main="Priority map")
watershed(im,p) %>% plot(main="Watershed transform")
```

---

where	<i>Return locations in pixel set</i>
-------	--------------------------------------

---

### Description

Return locations in pixel set

### Usage

```
where(x)
```

**Arguments**

x                    a pixset

**Examples**

```
#All pixel locations with value greater than .99  
where(boats > .99)
```

---

%inr%                    *Check that value is in a range*

---

**Description**

A shortcut for  $x \geq a \mid x \leq b$ .

**Usage**

x %inr% range

**Arguments**

x                    numeric values  
range                a vector of length two, of the form c(a,b)

**Value**

a vector of logicals 1:10

**Author(s)**

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