

Package ‘CTRing’

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Type Package

Title Density Profiles of Wood from CT Scan Images

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Description Computerized tomography (CT) can be used to assess certain wood properties when wood disks or logs are scanned. Wood density profiles (i.e. variations of wood density from pith to bark) can yield important information used for studies in forest resource assessment, wood quality and dendrochronology studies. The first step consists in transforming grey values from the scan images to density values. The packages then proposes a unique method to automatically locate the pith by combining an adapted Hough Transform method and a one-dimensional edge detector. Tree ring profiles (average ring density, earlywood and latewood density, ring width and percent latewood for each ring) are then obtained.

License GPL-3

Encoding UTF-8

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Suggests knitr, rmarkdown

VignetteBuilder knitr

Depends xRing, functional, oro.dicom

NeedsCompilation no

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addRingFromImage	<i>Add ring to pith to bark profile from CT scan image</i>
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Description

Add ring to pith to bark profile from CT scan image

Usage

addRingFromImage(n = 1, densProfile, im)

Arguments

- | | |
|-------------|------------------------|
| n | Number of rings to add |
| densProfile | Density profile |
| im | Density matrix |

Value

Corrected density profile with new ring(s) added and blue bar in plot of added ring

Examples

```

library(oro.dicom)
file_path <- system.file("extdata", "disk.dcm", package = "CTRing")
dcm <- readDICOM(file_path)
hdr_df <- dcm$hdr[[1]]
image_info <- getImageInfo(hdr = hdr_df)

im <- imageToMatrix(dcm$img)
im_8bit <- xBitTo8Bit(im, image_info$grayScale)
image_info <- getImageInfo(hdr = hdr_df)
im_dens <- grayToDensity(im_8bit)

pith_coord <- detect_pith(im_dens,
                          n_segments = 12,
                          pixel = TRUE,
                          toPlot = FALSE)

endPath <- c(472, 284)

densPath <- extractProfile(im_dens,
                          image_info,
                          pith_coord,
                          endPath,
                          k = 2, r = 5,
                          threshold = 0.002)

newPath2 <- addRingFromImage(n = 1, densPath, im_dens)

```

addRingFromProfile	<i>Add ring to pith to bark profile from profile plot</i>
--------------------	---

Description

Add ring to pith to bark profile from profile plot

Usage

```
addRingFromProfile(n = 1, densProfile)
```

Arguments

n	Number of rings to add
densProfile	Density profile

Value

Corrected density profile with new ring(s) added and blue bar in plot of added ring

Examples

```

library(oro.dicom)
file_path <- system.file("extdata", "disk.dcm", package = "CTRing")
dcm <- readDICOM(file_path)
hdr_df <- dcm$hdr[[1]]
image_info <- getImageInfo(hdr = hdr_df)

im <- imageToMatrix(dcm$img)
im_8bit <- xBitTo8Bit(im, image_info$grayScale)
im_dens <- grayToDensity(im_8bit)

pith_coord <- detect_pith(im_dens, n_segments = 12, pixel = TRUE, toPlot = FALSE)

endPath <- c(472, 284) # manual
# not run - endPath <- locatePathEnd(im_dens, pith_coord) # using the image

path <- extractProfile(im_dens, image_info, pith_coord, endPath, k = 2, r = 5, threshold = 0.002)

plotProfile(path)
newPath <- addRingFromProfile(n = 1, path)

```

addYears

*Add years to series***Description**

Add years to series

Usage

```
addYears(lastYear, densProfile)
```

Arguments

lastYear	Last year of series
densProfile	Density profile

Value

Density profile with years

Examples

```

library(oro.dicom)
file_path <- system.file("extdata", "disk.dcm", package = "CTRing")
dcm <- readDICOM(file_path)
hdr_df <- dcm$hdr[[1]]
image_info <- getImageInfo(hdr = hdr_df)

```

```

im <- imageToMatrix(dcm$img)
im_8bit <- xBitTo8Bit(im, image_info$grayScale)
im_dens <- grayToDensity(im_8bit)

pith_coord <- detect_pith(im_dens, n_segments = 12, pixel = TRUE, toPlot = FALSE)

endPath <- c(472, 284) # manual
# not run - endPath <- locatePathEnd(im_dens, pith_coord) # using the image

path <- extractProfile(im_dens, image_info, pith_coord, endPath, k = 2, r = 5, threshold = 0.002)

path <- addYears(2021, path)

```

calcAvgDens	<i>Calculate average wood, earlywood and latewood density for every ring</i>
-------------	--

Description

Calculate average wood, earlywood and latewood density for every ring

Usage

```
calcAvgDens(densProfile)
```

Arguments

densProfile Density profile

Value

List with several vectors

Examples

```

library(oro.dicom)
file_path <- system.file("extdata", "disk.dcm", package = "CTRing")
dcm <- readDICOM(file_path)
hdr_df <- dcm$hdr[[1]]
image_info <- getImageInfo(hdr = hdr_df)

im <- imageToMatrix(dcm$img)
im_8bit <- xBitTo8Bit(im, image_info$grayScale)
im_dens <- grayToDensity(im_8bit)

pith_coord <- detect_pith(im_dens, n_segments = 12, pixel = TRUE, toPlot = FALSE)

endPath <- c(472, 284) # manual
# not run - endPath <- locatePathEnd(im_dens, pith_coord) # using the image

```

```

path <- extractProfile(im_dens, image_info, pith_coord, endPath, k = 2, r = 5, threshold = 0.002)

pathEwLw <- getEwLw(path)
plotProfile(pathEwLw)
path_avgDens <- calcAvgDens(pathEwLw)
names(path_avgDens)

```

checkProfile	<i>Verify position of ring transitions of a density profile</i>
--------------	---

Description

Verify position of ring transitions of a density profile

Usage

```
checkProfile(profile_with_borders, totRings)
```

Arguments

profile_with_borders	xRing profile with transitions between rings located
totRings	Total number of rings of the disk

Value

xRing profile with corrected ring location

Examples

```

library(oro.dicom)
file_path <- system.file("extdata", "disk.dcm", package = "CTRing")
dcm <- readDICOM(file_path)
hdr_df <- dcm$hdr[[1]]
image_info <- getImageInfo(hdr = hdr_df)

im <- imageToMatrix(dcm$img)
im_8bit <- xBitTo8Bit(im, image_info$grayScale)
image_info <- getImageInfo(hdr = hdr_df)
im_dens <- grayToDensity(im_8bit)

pith_coord <- detect_pith(im_dens,
                          n_segments = 12,
                          pixel = TRUE,
                          toPlot = FALSE)

endPath <- c(472, 284)

```

```

densPath <- extractProfile(im_dens,
                           image_info,
                           pith_coord,
                           endPath,
                           k = 2, r = 5,
                           threshold = 0.002)

newPath <- checkProfile(densPath, 26)

```

deleteRingFromImage *Add ring to pith to bark profile from CT scan image*

Description

Add ring to pith to bark profile from CT scan image

Usage

```
deleteRingFromImage(n = 1, densProfile, im)
```

Arguments

n	Number of rings to remove
densProfile	Density profile
im	Density matrix

Value

Corrected density profile with ring(s) removed and red bar in plot of deleted ring

Examples

```

library(oro.dicom)
file_path <- system.file("extdata", "disk.dcm", package = "CTRing")
dcm <- readDICOM(file_path)
hdr_df <- dcm$hdr[[1]]
image_info <- getImageInfo(hdr = hdr_df)

im <- imageToMatrix(dcm$img)
im_8bit <- xBitTo8Bit(im, image_info$grayScale)
im_dens <- grayToDensity(im_8bit)

pith_coord <- detect_pith(im_dens, n_segments = 12, pixel = TRUE, toPlot = FALSE)

endPath <- c(472, 284) # manual

densPath <- extractProfile(im_dens,
                           image_info,
                           pith_coord,

```

```

        endPath,
        k = 2, r = 5,
        threshold = 0.002)

newPath2 <- addRingFromImage(n = 1, densPath, im_dens)
oldPath2 <- deleteRingFromImage(n = 1, densPath, im_dens)

```

deleteRingFromProfile *Delete ring from a pith to bark profile*

Description

Delete ring from a pith to bark profile

Usage

```
deleteRingFromProfile(n = 1, densProfile)
```

Arguments

n	Number of rings to remove
densProfile	Density profile

Value

Corrected density profile with ring(s) removed and red bar in plot of deleted ring

Examples

```

library(oro.dicom)
file_path <- system.file("extdata", "disk.dcm", package = "CTRing")
dcm <- readDICOM(file_path)
hdr_df <- dcm$hdr[[1]]
image_info <- getImageInfo(hdr = hdr_df)

im <- imageToMatrix(dcm$img)
im_8bit <- xBitTo8Bit(im, image_info$grayScale)
im_dens <- grayToDensity(im_8bit)

pith_coord <- detect_pith(im_dens, n_segments = 12, pixel = TRUE, toPlot = FALSE)

endPath <- c(472, 284) # manual
# not run - endPath <- locatePathEnd(im_dens, pith_coord) # using the image

densPath <- extractProfile(im_dens,
                           image_info,
                           pith_coord,
                           endPath,
                           k = 2, r = 5,

```

```

threshold = 0.002)

plotProfile(densPath)
newPath <- addRingFromProfile(n = 1, densPath)
oldPath <- deleteRingFromProfile(n = 1, newPath)

```

densityDataFrame	<i>Convert to dataframe</i>
------------------	-----------------------------

Description

Convert to dataframe

Usage

```
densityDataFrame(densProfile, sampleID = "NoID", addTransitionType = FALSE)
```

Arguments

densProfile	Density profile
sampleID	Sample ID
addTransitionType	add transition type to dataframe

Value

Dataframe with cambial age, density, years, transition type

Examples

```

library(oro.dicom)
file_path <- system.file("extdata", "disk.dcm", package = "CTRing")
dcm <- readDICOM(file_path)
hdr_df <- dcm$hdr[[1]]
image_info <- getImageInfo(hdr = hdr_df)

im <- imageToMatrix(dcm$img)
im_8bit <- xBitTo8Bit(im, image_info$grayScale)
im_dens <- grayToDensity(im_8bit)

pith_coord <- detect_pith(im_dens, n_segments = 12, pixel = TRUE, toPlot = FALSE)

endPath <- c(472, 284) # manual
# not run - endPath <- locatePathEnd(im_dens, pith_coord) # using the image

path <- extractProfile(im_dens, image_info, pith_coord, endPath, k = 2, r = 5, threshold = 0.002)

pathEwLw <- getEwLw(path)
plotProfile(pathEwLw)

```

```
path_avgDens <- calcAvgDens(pathEwLw)
densityDf <- densityDataFrame(pathEwLw)
```

detect_pith	<i>Automatically detect pith in a CT scan image</i>
-------------	---

Description

Automatically detect pith in a CT scan image

Usage

```
detect_pith(
  im,
  toPlot = TRUE,
  n_segments = 25,
  flag = TRUE,
  x_0 = 0.5,
  y_0 = 0.5,
  n_run_max = 15,
  threshold = 0.1,
  pixel = TRUE
)
```

Arguments

im	Matrix of the CT scan image
toPlot	Boolean to plot the location of the pith on the image
n_segments	Number of segments used to locate pith
flag	FALSE if pith location is known
x_0	Estimate of pith location in x
y_0	Estimate of pith location in y
n_run_max	Maximum number of iterations
threshold	Threshold value for identifying ring transition points
pixel	If TRUE, returns x,y coordinates in pixel numbers, else FALSE returns x,y coordinates in relative values of x and y

Value

x,y pith coordinates

Examples

```
library(oro.dicom)
file_path <- system.file("extdata", "disk.dcm", package = "CTRing")
dcm <- readDICOM(file_path)
hdr_df <- dcm$hdr[[1]]
image_info <- getImageInfo(hdr = hdr_df)

im <- imageToMatrix(dcm$img)
im_8bit <- xBitTo8Bit(im, image_info$grayScale)
im_dens <- grayToDensity(im_8bit)

pith_coord <- detect_pith(im_dens, n_segments = 12, pixel = TRUE, toPlot = FALSE)
```

extractProfile	<i>Get profile between two points of the CTScan image matrix</i>
----------------	--

Description

Get profile between two points of the CTScan image matrix

Usage

```
extractProfile(
  im,
  imHeader,
  beginPath,
  endPath,
  r = 10,
  k = 2,
  threshold = 0.01
)
```

Arguments

im	Density matrix
imHeader	image header
beginPath	X,Y coordinates of the start point of the path
endPath	X,Y coordinates of the start point of the path
r	Profile width
k	Rolling window width, integer
threshold	Threshold value between maximum and minimum density to establish change of ring

Value

Density profile

Examples

```

library(oro.dicom)
file_path <- system.file("extdata", "disk.dcm", package = "CTRing")
dcm <- readDICOM(file_path)
hdr_df <- dcm$hdr[[1]]
image_info <- getImageInfo(hdr = hdr_df)

im <- imageToMatrix(dcm$img)
im_8bit <- xBitTo8Bit(im, image_info$grayScale)
im_dens <- grayToDensity(im_8bit)

pith_coord <- detect_pith(im_dens, n_segments = 12, pixel = TRUE, toPlot = FALSE)

endPath <- c(472, 284) # manual
# not run - endPath <- locatePathEnd(im_dens, pith_coord) # using the image

path <- extractProfile(im_dens, image_info, pith_coord, endPath, k = 2, r = 5, threshold = 0.002)

```

getEwLw

Establish the transition point from earlywood to latewood for a series of rings

Description

Establish the transition point from earlywood to latewood for a series of rings

Usage

```
getEwLw(densProfile)
```

Arguments

densProfile Density profile

Value

xRingList with EW to LW transition points with transition type added (1: low number of points in ring; 2: inflexion point estimated by polynomial; 3: min or max are out of range; 4: inflexion point close to min or max; 5: convex-concave)

Examples

```

library(oro.dicom)
file_path <- system.file("extdata", "disk.dcm", package = "CTRing")
dcm <- readDICOM(file_path)
hdr_df <- dcm$hdr[[1]]
image_info <- getImageInfo(hdr = hdr_df)

```

```

im <- imageToMatrix(dcm$img)
im_8bit <- xBitTo8Bit(im, image_info$grayScale)
im_dens <- grayToDensity(im_8bit)

pith_coord <- detect_pith(im_dens, n_segments = 12, pixel = TRUE, toPlot = FALSE)

endPath <- c(472, 284) # manual
# not run - endPath <- locatePathEnd(im_dens, pith_coord) # using the image

path <- extractProfile(im_dens, image_info, pith_coord, endPath, k = 2, r = 5, threshold = 0.002)

pathEwLw <- getEwLw(path)

densityDf <- densityDataFrame(path)

```

getImageInfo	<i>Extract from header of CT scan image grayscale number of bits and pixel size</i>
--------------	---

Description

Extract from header of CT scan image grayscale number of bits and pixel size

Usage

```
getImageInfo(hdr)
```

Arguments

hdr	Header dataframe
-----	------------------

Value

List with grayscale values, and pixel size

Examples

```

library(oro.dicom)
file_path <- system.file("extdata", "disk.dcm", package = "CTRing")
dcm <- readDICOM(file_path)
hdr_df <- dcm$hdr[[1]]
getImageInfo(hdr = hdr_df)

```

grayToDensity	<i>Convert from 8bit gray scale to density</i>
---------------	--

Description

Convert from 8bit gray scale to density

Usage

```
grayToDensity(im, a = -0.1321, b = 0.01834)
```

Arguments

- im Matrix of CT scan image in 8bit gray scale
- a Intercept of the calibration curve
- b Slope of the calibration curve

Value

Matrix of density values

Examples

```
library(oro.dicom)
file_path <- system.file("extdata", "disk.dcm", package = "CTRing")
dcm <- readDICOM(file_path)
hdr_df <- dcm$hdr[[1]]
image_info <- getImageInfo(hdr = hdr_df)

im <- imageToMatrix(dcm$img)
im_8bit <- xBitTo8Bit(im, image_info$grayScale)
range(im_8bit)

im_dens <- grayToDensity(im_8bit)
range(im_dens)
```

imageToMatrix	<i>Convert dicom image to matrix</i>
---------------	--------------------------------------

Description

Convert dicom image to matrix

Usage

```
imageToMatrix(img)
```

Arguments

img Dicom image

Value

Matrix of image

Examples

```
library(oro.dicom)
file_path <- system.file("extdata", "disk.dcm", package = "CTRing")
dcm <- readDICOM(file_path)
hdr_df <- dcm$hdr[[1]]
image_info <- getImageInfo(hdr = hdr_df)

im <- imageToMatrix(dcm$img)
dim(im)
image(im)
```

locatePathEnd	<i>Get coordinates of the end of the path on a CT scan image</i>
---------------	--

Description

Get coordinates of the end of the path on a CT scan image

Usage

```
locatePathEnd(im, pithCoord)
```

Arguments

im CT scan image
pithCoord X,Y coordinates of the pith

Value

Coordinates of the end of the path

Examples

```
library(oro.dicom)
file_path <- system.file("extdata", "disk.dcm", package = "CTRing")
dcm <- readDICOM(file_path)
hdr_df <- dcm$hdr[[1]]
image_info <- getImageInfo(hdr = hdr_df)

im <- imageToMatrix(dcm$img)
```

```

im_8bit <- xBitTo8Bit(im, image_info$grayScale)
im_dens <- grayToDensity(im_8bit)

pith_coord <- detect_pith(im_dens, n_segments = 12, pixel = TRUE, toPlot = FALSE)

endPath <- c(472, 284) # manual
# not run - endPath <- locatePathEnd(im_dens, pith_coord) # using the image

```

pithCoordinates	<i>convert pith coordinates from pixels to length units</i>
-----------------	---

Description

convert pith coordinates from pixels to length units

Usage

```
pithCoordinates(pith_coord, pixel_size_x, pixel_size_y)
```

Arguments

pith_coord	Pith coordinates in pixels
pixel_size_x	Pixel size in x
pixel_size_y	Pixel size in y

Value

Pixel coordinates in length units

plotImageProfile	<i>Plot scan image, profile path and ring limits</i>
------------------	--

Description

Plot scan image, profile path and ring limits

Usage

```
plotImageProfile(densProfile, im)
```

Arguments

densProfile	Density profile
im	Density matrix

Value

Plot

Examples

```
library(oro.dicom)
file_path <- system.file("extdata", "disk.dcm", package = "CTRing")
dcm <- readDICOM(file_path)
hdr_df <- dcm$hdr[[1]]
image_info <- getImageInfo(hdr = hdr_df)

im <- imageToMatrix(dcm$img)
im_8bit <- xBitTo8Bit(im, image_info$grayScale)
im_dens <- grayToDensity(im_8bit)

pith_coord <- detect_pith(im_dens, n_segments = 12, pixel = TRUE, toPlot = FALSE)

endPath <- c(472, 284) # manual

path <- extractProfile(im_dens, image_info, pith_coord, endPath, k = 2, r = 5, threshold = 0.002)

plotProfile(path)

plotImageProfile(path, im_dens)
```

plotProfile

Plot density profile

Description

Plot density profile

Usage

```
plotProfile(densProfile)
```

Arguments

densProfile Density profile

Value

Figure

Examples

```

library(oro.dicom)
file_path <- system.file("extdata", "disk.dcm", package = "CTRing")
dcm <- readDICOM(file_path)
hdr_df <- dcm$hdr[[1]]
image_info <- getImageInfo(hdr = hdr_df)

im <- imageToMatrix(dcm$img)
im_8bit <- xBitTo8Bit(im, image_info$grayScale)
im_dens <- grayToDensity(im_8bit)

pith_coord <- detect_pith(im_dens, n_segments = 12, pixel = TRUE, toPlot = FALSE)

endPath <- c(472, 284) # manual
# not run - endPath <- locatePathEnd(im_dens, pith_coord) # using the image

path <- extractProfile(im_dens, image_info, pith_coord, endPath, k = 2, r = 5, threshold = 0.002)

plotProfile(path)

```

relToPixel

Change from relative to fixed pixel coordinate system

Description

Change from relative to fixed pixel coordinate system

Usage

```
relToPixel(pith_coord, im)
```

Arguments

pith_coord	Pith coordinates in relative space (x, y)
im	Density matrix

Value

Pixel coordinates in number of pixels (x, y)

removeLastYear	<i>Remove the last year of a profile</i>
----------------	--

Description

Remove the last year of a profile

Usage

```
removeLastYear(densProfile)
```

Arguments

densProfile Density profile

Value

Density profile with the last year removed

Examples

```
library(oro.dicom)
file_path <- system.file("extdata", "disk.dcm", package = "CTRing")
dcm <- readDICOM(file_path)
hdr_df <- dcm$hdr[[1]]
image_info <- getImageInfo(hdr = hdr_df)

im <- imageToMatrix(dcm$img)
im_8bit <- xBitTo8Bit(im, image_info$grayScale)
im_dens <- grayToDensity(im_8bit)

pith_coord <- detect_pith(im_dens, n_segments = 12, pixel = TRUE, toPlot = FALSE)

endPath <- c(472, 284) # manual
# not run - endPath <- locatePathEnd(im_dens, pith_coord) # using the image

path <- extractProfile(im_dens, image_info, pith_coord, endPath, k = 2, r = 5, threshold = 0.002)
path_last_year_2021 <- addYears(2021, path)
path_last_year_2020 <- removeLastYear(path_last_year_2021)
```

verifyPith	<i>Check if pith location is correct</i>
------------	--

Description

Check if pith location is correct

Usage

```
verifyPith(im, pith_coord)
```

Arguments

im	Density matrix of image
pith_coord	Pith coordinates

Value

Corrected pith coordinates

Examples

```
library(oro.dicom)
file_path <- system.file("extdata", "disk.dcm", package = "CTRing")
dcm <- readDICOM(file_path)
hdr_df <- dcm$hdr[[1]]
image_info <- getImageInfo(hdr = hdr_df)

im <- imageToMatrix(dcm$img)
im_8bit <- xBitTo8Bit(im, image_info$grayScale)
im_dens <- grayToDensity(im_8bit)

pith_coord <- detect_pith(im_dens, n_segments = 12, pixel = TRUE, toPlot = FALSE)

pith_coord_checked <- verifyPith(im_dens, pith_coord)
```

xBitTo8Bit	<i>Convert gray scale from measured bits to 8bit</i>
------------	--

Description

Convert gray scale from measured bits to 8bit

Usage

```
xBitTo8Bit(im, bits)
```

Arguments

<code>im</code>	Matrix of values in x bits
<code>bits</code>	Number of bits of the original gray scale

Value

Matrix of gray scale values in 8bits

Examples

```
library(oro.dicom)
file_path <- system.file("extdata", "disk.dcm", package = "CTRing")
dcm <- readDICOM(file_path)
hdr_df <- dcm$hdr[[1]]
image_info <- getImageInfo(hdr = hdr_df)

im <- imageToMatrix(dcm$img)
range(im)

im_8bit <- xBitTo8Bit(im, image_info$grayScale)
range(im_8bit)
```

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