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

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NeedsCompilation no

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`addRingFromImage` *Add ring to pith to bark profile from CT scan image*

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` *Add ring to pith to bark profile from profile plot*

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` *Calculate average wood, earlywood and latewood density for every ring*

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 *Verify position of ring transitions of a density profile*

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 *Convert to dataframe*

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` *Automatically detect pith in a CT scan image*

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 segements 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`	Thershold 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` *Get profile between two points of the CTScan image matrix*

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

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 *Convert from 8bit gray scale to density*

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 *Convert dicom image to matrix*

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

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` *convert pith coordinates from pixels to length units*

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` *Plot scan image, profile path and ring limits*

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` *Remove the last year of a profile*

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 *Check if pith location is correct*

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 *Convert gray scale from measured bits to 8bit*

Description

Convert gray scale from measured bits to 8bit

Usage

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

Arguments

im	Matrix of values in x bits
bits	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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