Package ‘tvR’

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Type Package
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Description Provides tools for denoising noisy signal and images via Total Variation Regularization. Reducing the total variation of the given signal is known to remove spurious detail while preserving essential structural details. For the seminal work on the topic, see Rudin et al (1992) <doi:10.1016/0167-2789(92)90242-F>.
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Author Kisung You [aut, cre] (<https://orcid.org/0000-0002-8584-459X>)
Maintainer Kisung You <kyoustat@gmail.com>
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tvR-package  

**tvR** : *Total Variation Regularization*

**Description**

**tvR** provides tools for denoising noisy signal and images via Total Variation Regularization. Reducing the total variation of the given signal is known to remove spurious detail while preserving essential structural details. For now, we provide tools for denoising only on 1-dimensional signals or 2-dimensional images, where the latter be represented as 2d or 3d array.

```
denoise1
```

**Total Variation Denoising for Signal**

**Description**

Given a 1-dimensional signal \( f \), it solves an optimization of the form,

\[
u^* = \arg\min_u E(u, f) + \lambda V(u)
\]

where \( E(u, f) \) is fidelity term and \( V(u) \) is total variation regularization term. The naming convention of a parameter method is `<problem type>` + `<name of algorithm>`. For more details, see the section below.

**Usage**

```
denoise1(signal, lambda = 1, niter = 100, method = c("TVL2.IC", "TVL2.MM"))
```

**Arguments**

- `signal` : vector of noisy signal.
- `lambda` : regularization parameter (positive real number).
- `niter` : total number of iterations.
- `method` : indicating problem and algorithm combination.

**Value**

a vector of same length as input signal.
Algorithms for TV-L2 problem

The cost function for TV-L2 problem is

\[
\min_u \frac{1}{2} |u - f|^2 + \lambda |\nabla u|
\]

where for a given 1-dimensional vector, \( |\nabla u| = \sum |u_{i+1} - u_i| \). Algorithms (in conjunction with model type) for this problems are

"TVL2.IC" Iterative Clipping algorithm.
"TVL2.MM" Majorization-Minorization algorithm.

The codes are translated from MATLAB scripts by Ivan Selesnick.

References


Examples

```r
## generate a stepped signal
x = rep(sample(1:5,10,replace=TRUE), each=50)

## add some additive white noise
xnoised = x + rnorm(length(x), sd=0.25)

## apply denoising process
xproc1 = denoise1(xnoised, method = "TVL2.IC")
xproc2 = denoise1(xnoised, method = "TVL2.MM")

## plot noisy and denoised signals
plot(xnoised, pch=19, cex=0.1, main="Noisy signal")
lines(xproc1, col="blue", lwd=2)
lines(xproc2, col="red", lwd=2)
legend("bottomleft",legend=c("Noisy","TVL2.IC","TVL2.MM"),
col=c("black","blue","red"),# lty = c("solid", "solid", "solid"),
lwd = c(0, 2, 2), pch = c(19, NA, NA),
pt.cex = c(1, NA, NA), inset = 0.05)
```
**Total Variation Denoising for Image**

**Description**

Given an image $f$, it solves an optimization of the form,

$$ u^* = \text{argmin}_u E(u, f) + \lambda V(u) $$

where $E(u, f)$ is fidelity term and $V(u)$ is total variation regularization term. The naming convention of a parameter method is `<problem type> + <name of algorithm>`. For more details, see the section below.

**Usage**

```r
denoise2(data, lambda = 1, niter = 100, method = c("TVL1.PrimalDual", "TVL2.PrimalDual", "TVL2.FiniteDifference"), normalize = FALSE)
```

**Arguments**

- `data` standard 2d or 3d array.
- `lambda` regularization parameter (positive real number).
- `niter` total number of iterations.
- `method` indicating problem and algorithm combination.
- `normalize` a logical; TRUE to make the range in $[0,1]$, or FALSE otherwise.

**Value**

denoised array as same size of data.

**Data format**

An input `data` can be either (1) 2-dimensional matrix representing grayscale image, or (2) 3-dimensional array for color image.

**Algorithms for TV-L1 problem**

The cost function for TV-L2 problem is

$$ \min_u |u - f|_1 + \lambda |\nabla u| $$

where for a given 2-dimensional array, $|\nabla u| = \sum \sqrt{u_x^2 + u_y^2}$ Algorithms (in conjunction with model type) for this problems are

"TVL1.PrimalDual" Primal-Dual algorithm.
Algorithms for TV-L2 problem

The cost function for TV-L2 problem is

$$\min_u |u - f|^2 + \lambda |\nabla u|$$

and algorithms (in conjunction with model type) for this problems are

"TVL2.PrimalDual" Primal-Dual algorithm.

"TVL2.FiniteDifference" Finite Difference scheme with fixed point iteration.

References


Examples

```r
## Not run:
## Load grey-scale 'lena' data
data(lena128)

## Add white noise
sinfo <- dim(lena128)  # get the size information
xnoised <- lena128 + array(rnorm(128*128, sd=10), sinfo)

## apply denoising models
xproc1 <- denoise2(xnoised, lambda=10, method="TVL2.FiniteDifference")
xproc2 <- denoise2(xnoised, lambda=10, method="TVL1.PrimalDual")

## compare
gcol = gray(0:256/256)
x11()
par(mfrow=c(2,2), pty="s")
image(lena128, main="original", col=gcol)
image(xnoised, main="noised", col=gcol)
image(xproc1, main="TVL2.FiniteDifference", col=gcol)
image(xproc2, main="TVL1.PrimalDual", col=gcol)

## End(Not run)
```
Description

Lena is probably one of the most well-known example in image processing and computer vision. Well, here is a brief introduction on the story of Lena.

Usage

data(lena128)

Format

matrix of size \((128 \times 128)\)

Source

USC SIPI Image Database

References


Examples

data(lena128)
image(lena128, col=gray((0:100)/100), axes=FALSE, main="lena128")
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