An overview of `rlpSpec`: Adaptive sine multitaper power spectral density estimation

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Abstract

The purpose of this vignette is to provide an overview of the features included in `rlpSpec`. One can also find information through the help info: `rlpSpec-package`

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1 Quick start: A minimal example.

We need a datasource to begin with:

```
> library(rlpSpec)
> data(magsat)
```

Setting assumptions regarding the stationarity of the series aside, we can find power spectral density estimates for these data quite simply:

```
> psd1 <- pspectrum(magsat$raw)
> psd2 <- pspectrum(magsat$clean)
```

which performs four iterations of adaptive taper refinement.

Finally, we can compare the two. Since `pspectrum` returns an object with class `spec`, we have access to methods within `stats`. Note the drastic improvement in both variance and bias between the two series: `magsat$clean` is free of large, instrumental artefacts and shows a very red spectrum typically found in geophysical datasets.

```
> plot(psd2, log="dB")
> lines(psd1$freq, 10*log10(psd1$spec), col="red")
```

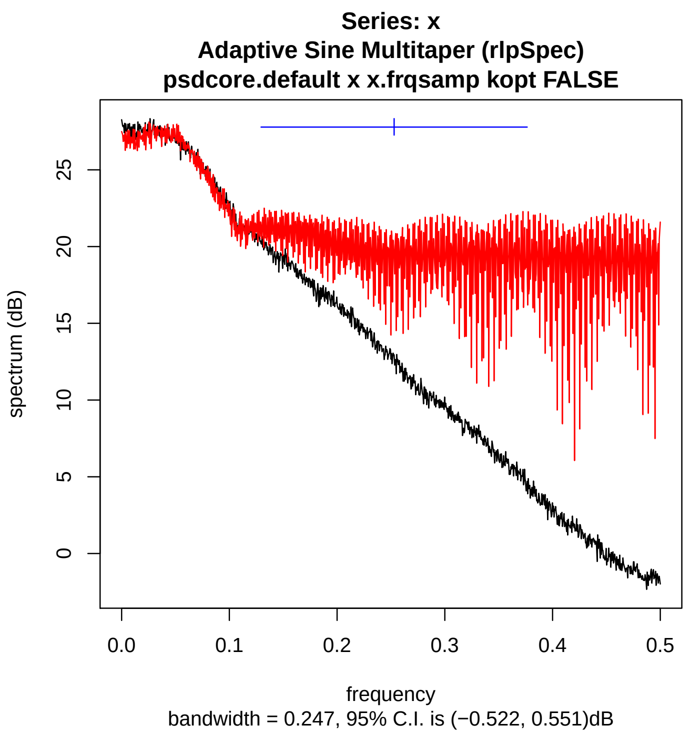

Figure 1: Comparison of power spectral densities for the `MAGSAT` data included with `rlpSpec`.

2 Comparisons with other methods

As shown in the MAGSAT example, we are concerned with improving variance and bias to gain an improved understanding of the physics behind the signals in the data. But how does this method compare with other methods?

2.1 `stats::spectrum`

Included in the core distribution of R is `stats::spectrum`, which accesses `stats::spec.ar` or `stats::spec.pgram` for either parametric and non-parametric estimation, respectively. Our method is non-parametric; hence, we will compare to the latter.

Included in `rlpSpec::psdcore` is an optional argument to compare the results with a naive estimator|the raw periodogram. In R this is equivalent to

```
> spec.pgram(X, log="no", pad=1, taper=0, detrend=FALSE, demean=FALSE, plot=F)
```

Returning to the previous dataset, let's compare the methods for the `clean` data, but `psdcore` does not clear the working environment, so we do that first:

```
> rlpSpec:::rlp_envClear()
```

and then re-calculate the PSDs using the optimized tapers and the raw periodogram (with `detrend <- demean <- TRUE`):

```
> str(rlp_envStatus())

List of 5
 $ env_name         : chr ".rlpSpecEnv"
 $ obviously_exists: logi TRUE
 $ listing          : chr "init"
 $ env_init         : chr "refreshed at 2013-01-23 15:53:04"
 $ env_status_stamp: POSIXct[1:1], format: "2013-01-23 15:53:04"

> ntap <- psd2$taper
> psdcore(magsat$clean, ntaper=ntap, plotpsd=TRUE)
> str(rlp_envStatus())

List of 5
 $ env_name         : chr ".rlpSpecEnv"
 $ obviously_exists: logi TRUE
 $ listing          : chr [1:8] "fft_even_demeaned_padded" "init" "len_even" "len_even_half"
 $ env_init         : chr "refreshed at 2013-01-23 15:53:04"
 $ env_status_stamp: POSIXct[1:1], format: "2013-01-23 15:53:05"
```

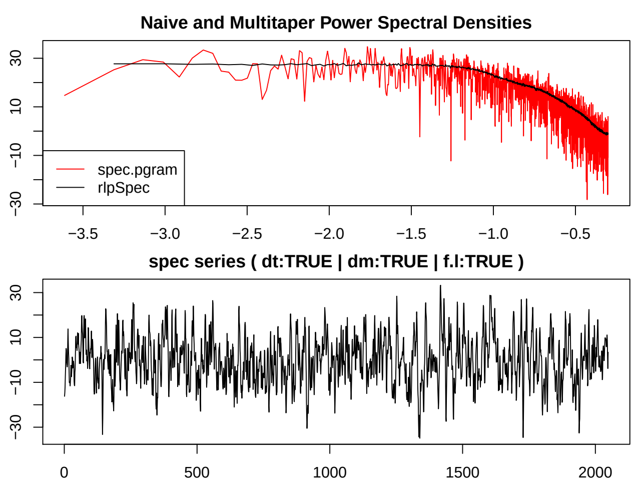

Figure 2: Comparison between naive and multitaper PSD estimators for the clean MAGSAT data.

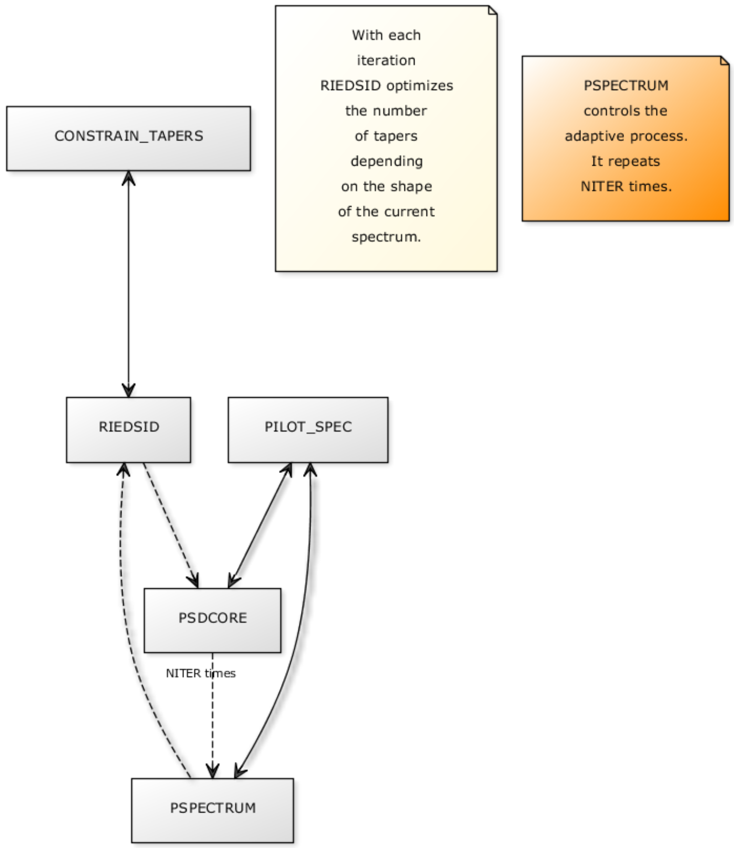

Figure 3: Simplified call graph.

References