lomb - periodogram of unevenly spaced time series

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Even a single missing or falsely read point can make a time series unevenly sampled. These data with varying time point increments cannot be analyzed for temporal patterns with traditional Fourier periodograms. However, Lomb (1976), followed by Scargle (1982) devised a method to investigate uneven time series. This is provided bv package lomb an the function lsp(), the Lomb-Scargle Periodogram.

For example, we can make the timeseries Lynx uneven by making ten points unavailable

```
missing=c(5,25,49,26,56,79,88,98,99,112)
lmiss=data.frame(year=1:114, capture=lynx)
lmiss[missing,]=NA
lmiss=na.omit(lmiss)

library(lomb)
result=lsp(lmiss)
```

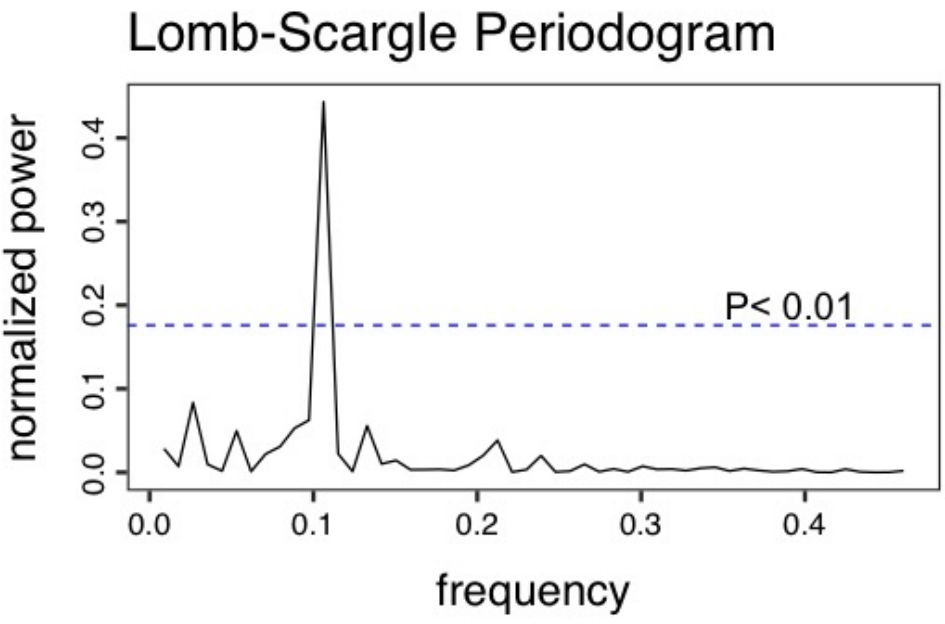

Figure 1: Lomb-Scargle Periodogram of the time series lynx with 5 missing points.

The increment between subsequent years now varies from 1 to 3. The outcome of lsp is a figure with a peak at a period of approximately 10 years (exactly stored in result$peak.at$). $In other words, there was a\ 10 year rhythm in Lynx trappings$

Sometimes, unevenly spaced series are generated by noting the time of a movement. This was done for a blind beetle and can be visualized in an actogram.

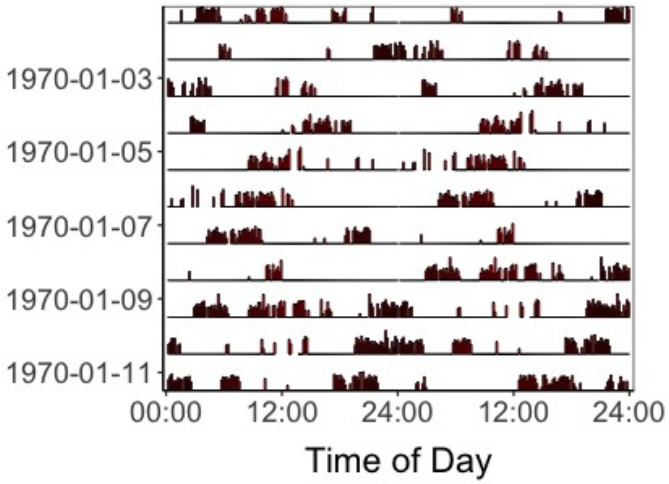

Figure 2: Actogram of locomotion of a blind beetle.us function actogram()

This 12 day double-plot of activity shows day1 and day2 in the first row, day2 and day3 in the second row, ans so on. A Lomb-Scargle periodogram of these data can be computed as follows.

```
data(caradat)
focus=actogram(caradat$Date, caradat$Activity, dble=TRUE, photo=FALSE, zone=1,from="1970-01-01 00:00:00
df=makedf (focus$date, focus$plotvar)
lsp(df, type="period",ofac=5,from=12,to=36)
```

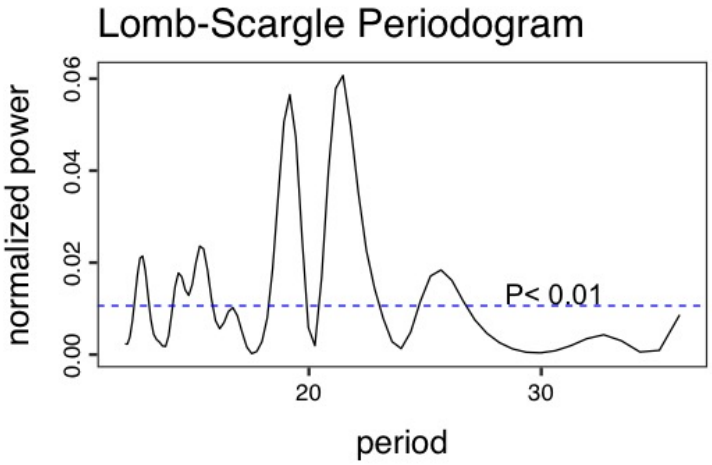

Figure 3: Lomb-Scargle Periodogram of the activity of a beetle shown before

The resutlting lsp, for the unique days shown previously, (here day 1-12) has major peaks at ~19-22 h, thus the rhythm is < 24 h. The periodorgam is shown for periods from 12 to 36 h. Ofac determines the

oversampling factor, which (without a statistical penalty) makes the periodogram smoother. Aside from other advantages, the lsp is highly sensitive to rhythmic signals (Ruf 1999).

References:

Lomb, N. R. (1976). Least-squares frequency analysis of unequally spaced data. Astrophysics and space science, 39, 447-462.

Scargle, J. D. (1982). Studies in astronomical time series analysis. II-Statistical aspects of spectral analysis of unevenly spaced data. Astrophysical Journal, Part 1, vol. 263, Dec. 15, 1982, p. 835-853., 263, 835-853.

Baluev, R. V. (2008). Assessing the statistical significance of periodogram peaks. Monthly Notices of the Royal Astronomical Society, 385(3), 1279-1285.

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