Cytel

Shaping the Future of Drug Development

Digital Signal Processing with R

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What is digital signal processing?

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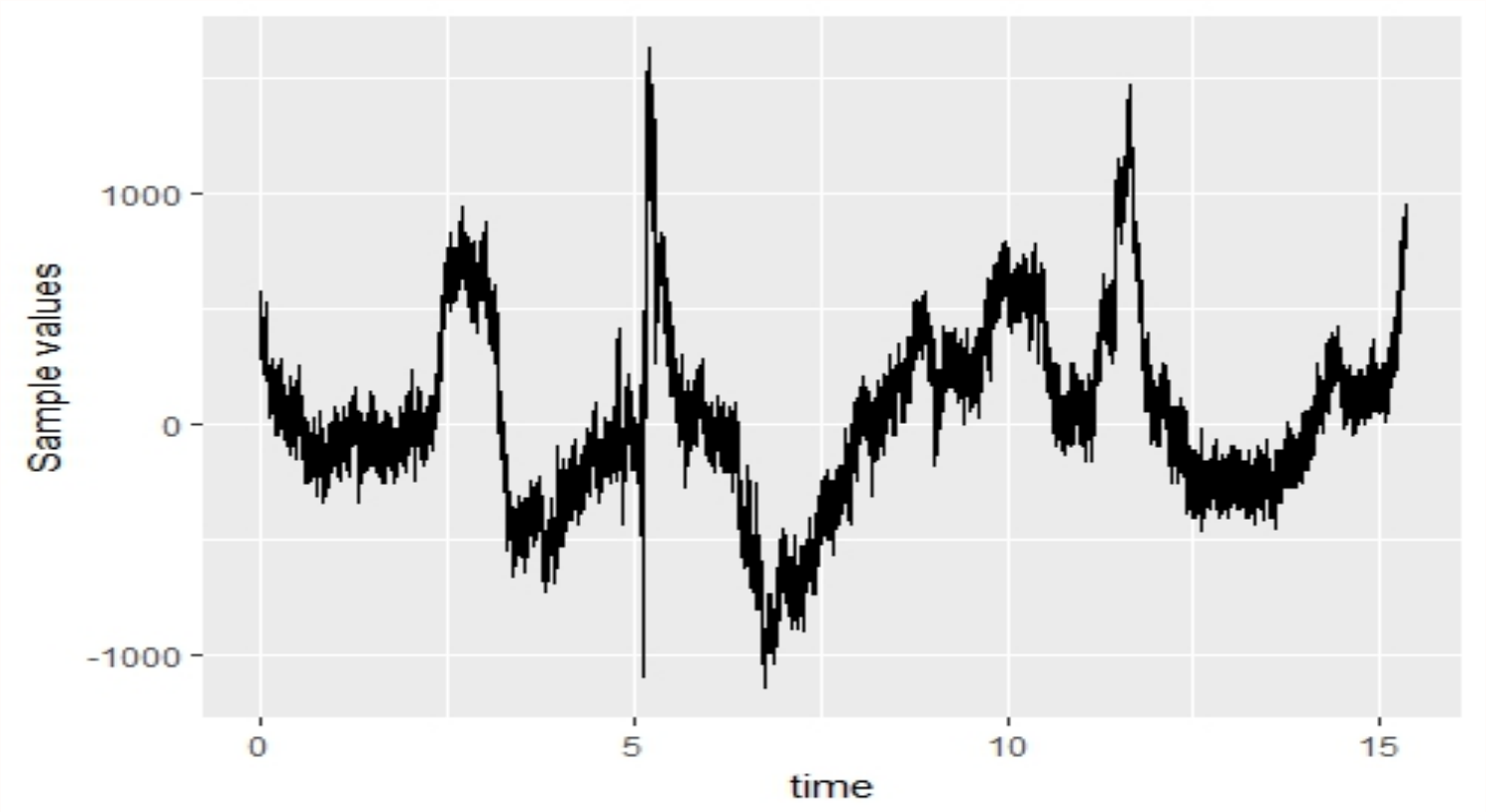
The input data

- A biomedical signal that measures a particular function of the human body, is sampled at 5 kHz.
- These signals are collected from a little while before the activity to a little after it.



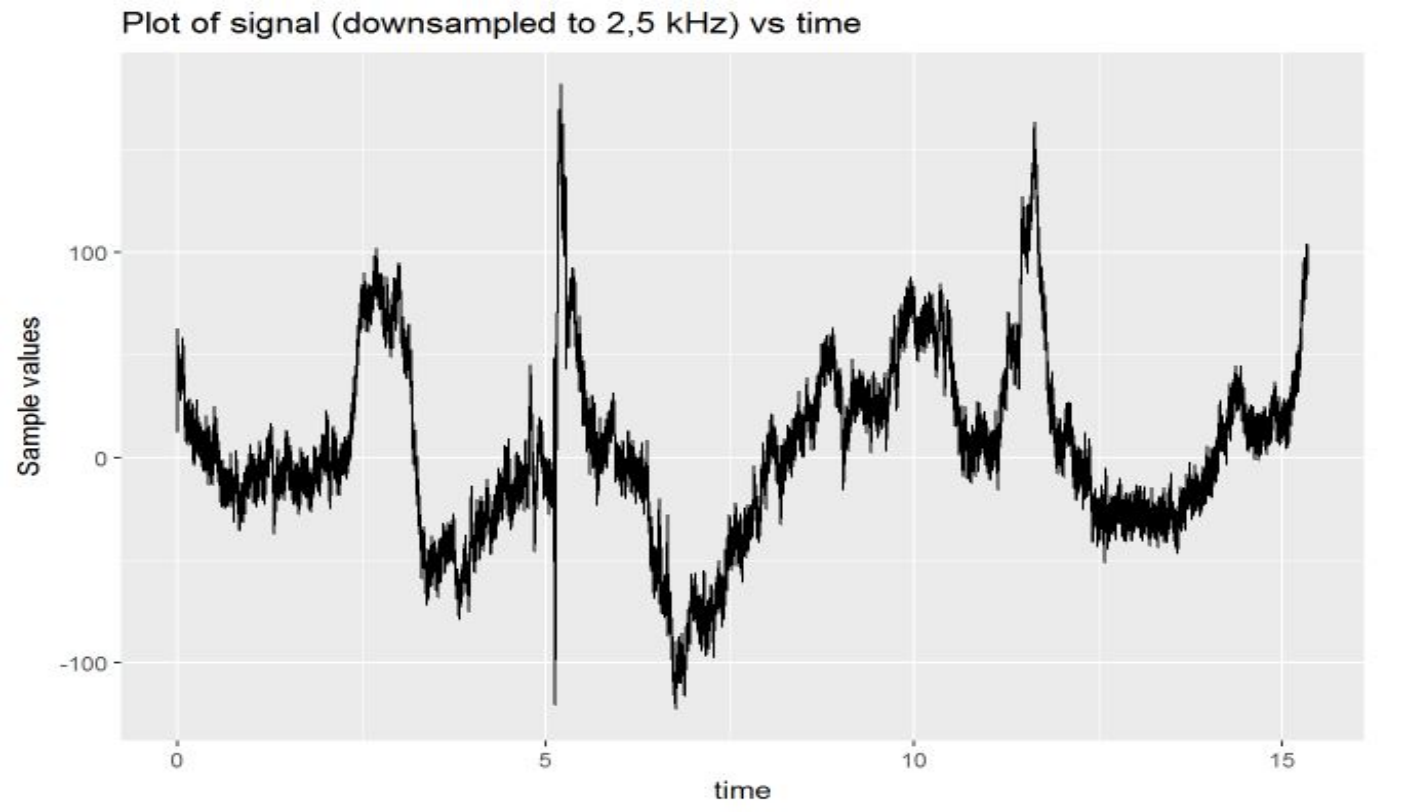
Objective & method of processing

- The objective is to locate the region of interest in the signal corresponding to the activity of interest.
- The power spectrum of the signal is analyzed to localize the region of interest.

Pre-processing of signals

- Low-pass filtering and down-sampling of the signal.

```
Coef <-  signal::butter(n = 2, W = 0.4, type = "low")
signal.lpf <- signal::filter(Coef$b, Coef$a, rawSignal)
signal.dwnsmple <- signal.lpf[seq(from = 1, length(rawSignal), by = 2)]
```



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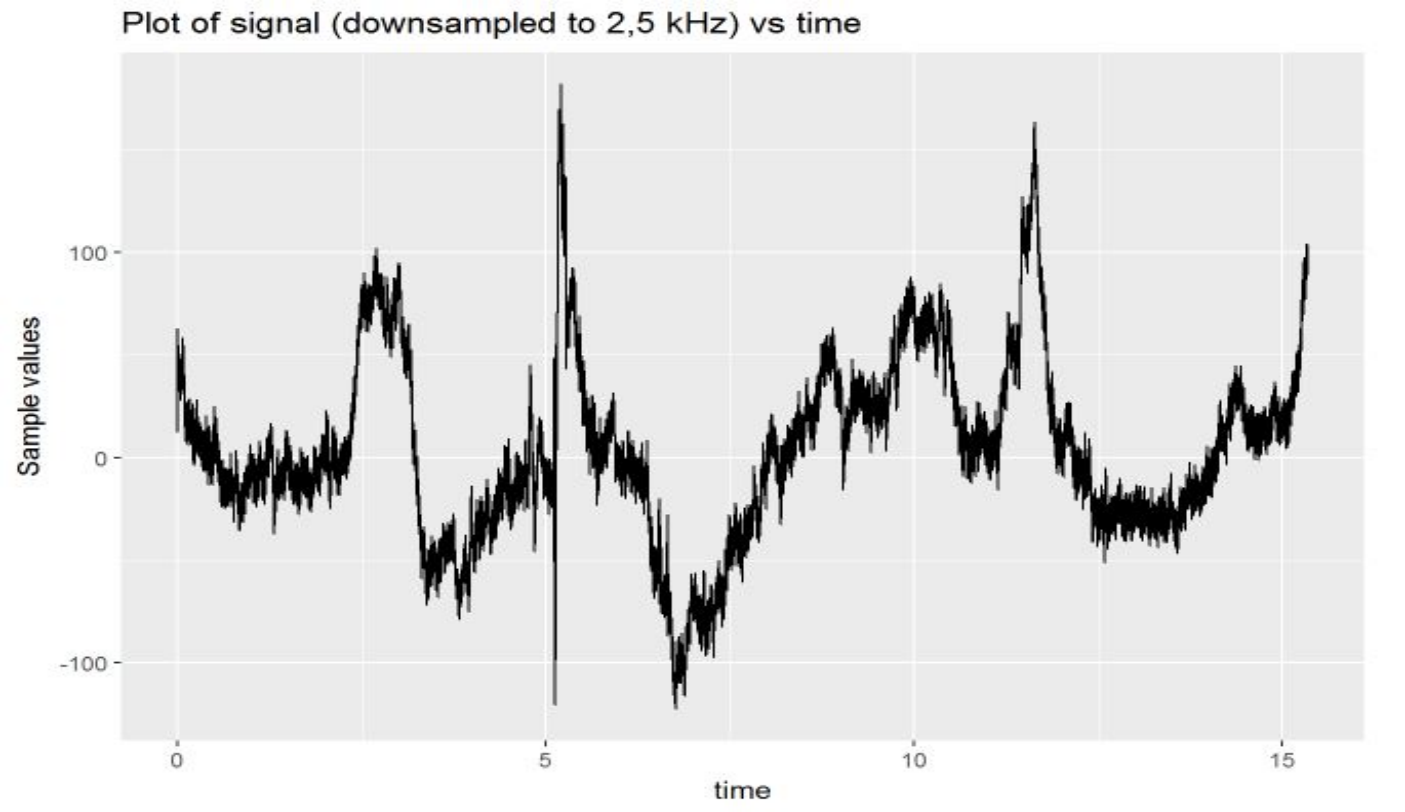

Power spectrum analysis

- Chop the signal into segments of fixed sizes and smooth before spectrum analysis.

```
signal.chopped <- chopSignal(signal.dwnsmple, 128, 256)
winWts <- e1071::hamming.window(256)
signal.weighted <- sweep(signal.chopped, MARGIN = 2, winWts, `*`)
```

- Transform the signal to the frequency domain and compute the power spectral density.

```
signal.fft <- t(apply(signal.weighted, MARGIN = 2, FUN = stats::fft))
signal.psd <- (Mod(signal.fft[, 1:129]))^2
signal.psd[, 2:129] <- 2*signal.psd[, 2:129]
```

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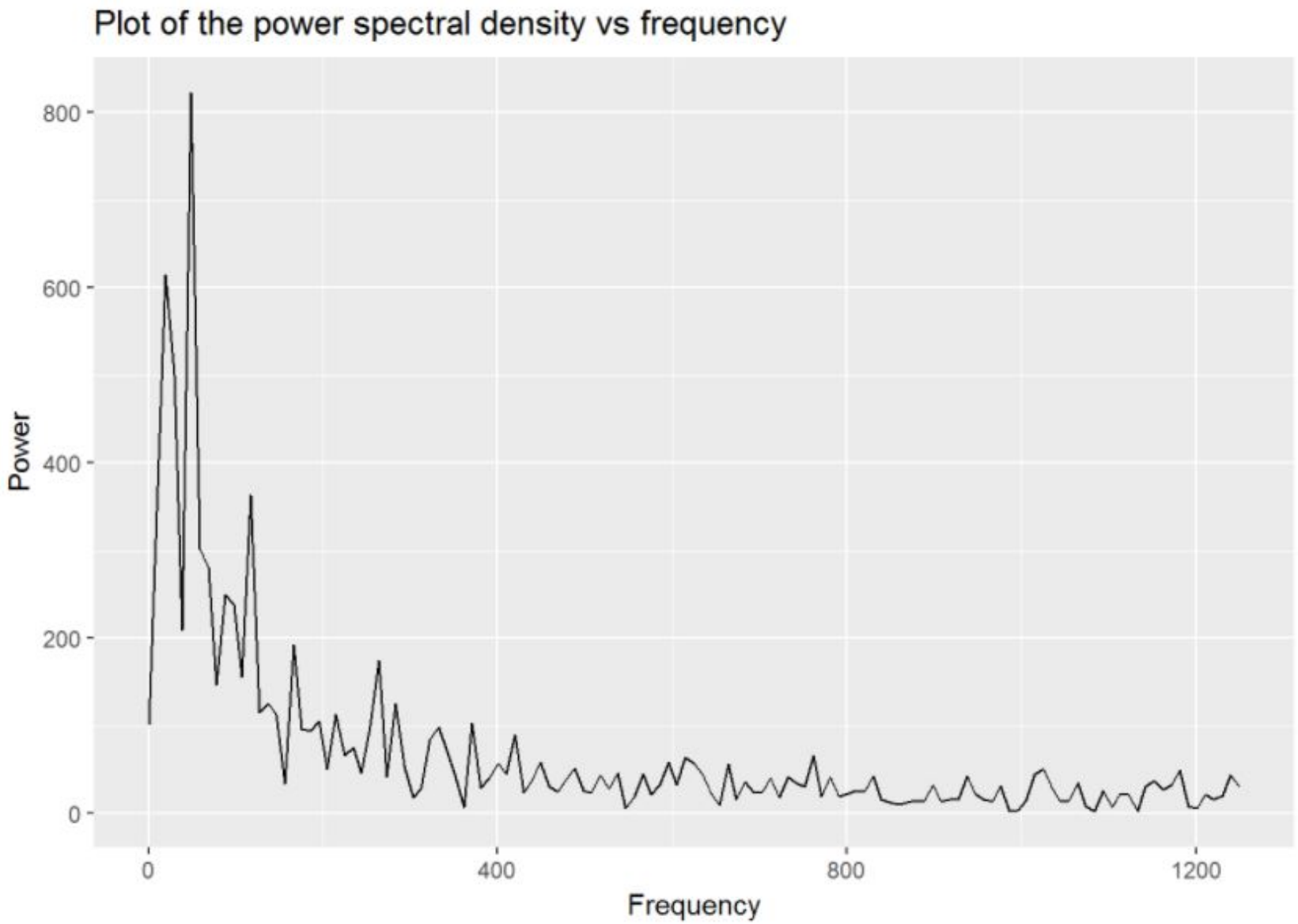
The power spectral density (PSD)

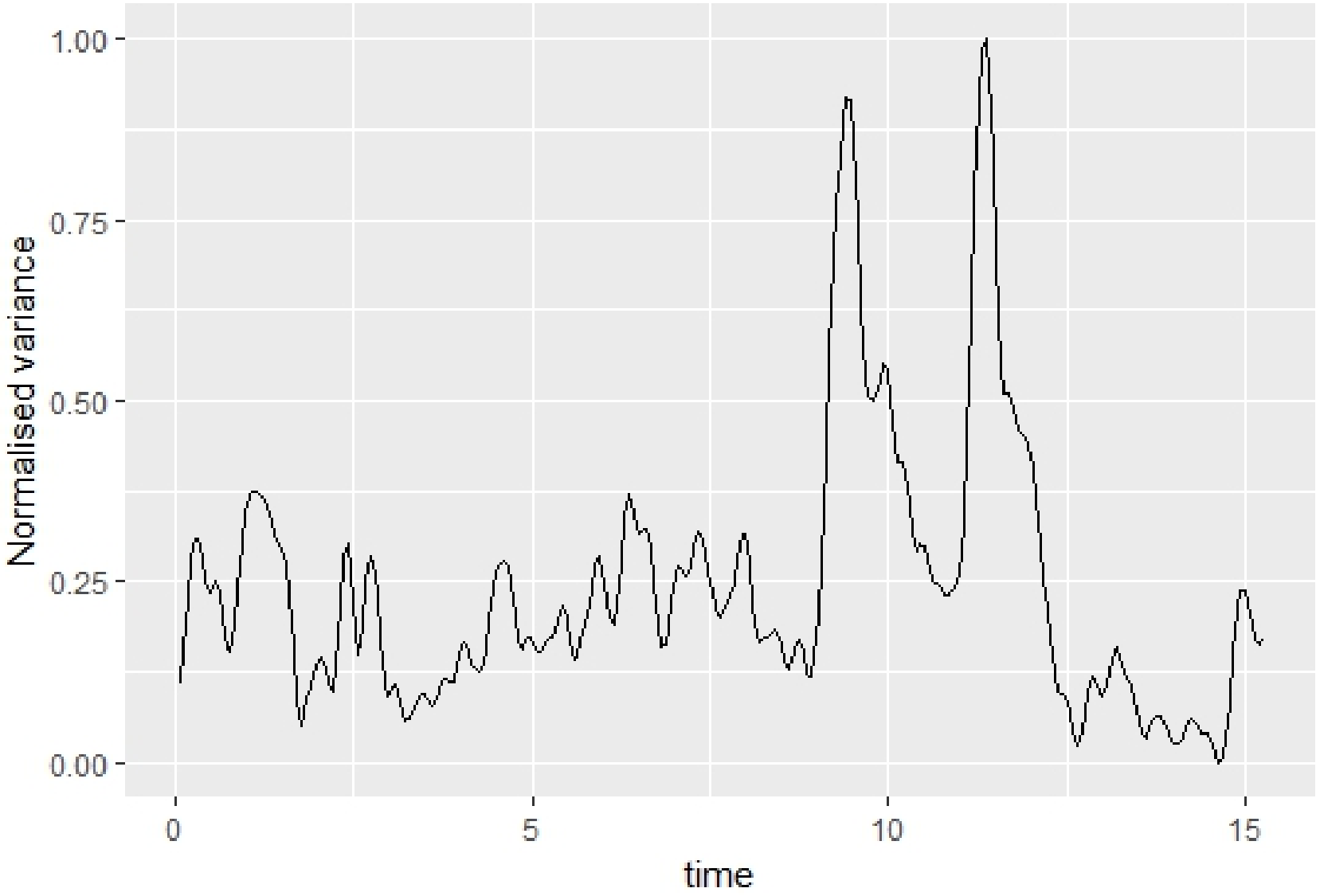


Segmentation of signals

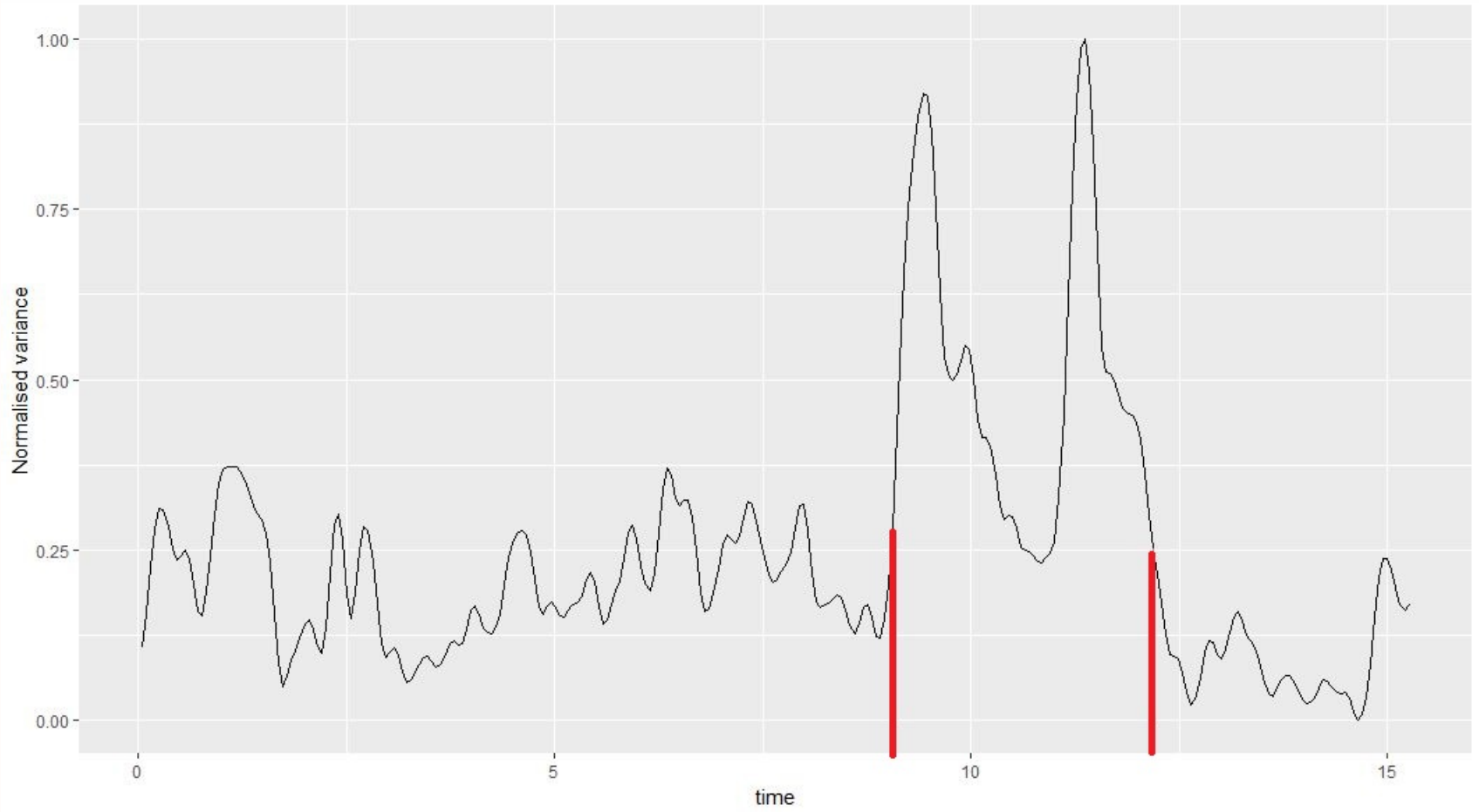
- Based on knowledge of the underlying physiological process, segment the PSD between appropriate frequencies.
- Compute the variance and smooth using a running window.

```
weightedPSD <- sweep(sigInterest, MARGIN = 2, weightWindow,`*` )
varBW0 <- (apply(weightedPSD, 1, sum))/sum(weightWindow)

padZeros <- floor(7/2)
x.padded <- c((rep(0, padZeros)), varBW0, (rep(0, padZeros)))
wincoeff <- hamming.window(7)
x.weighed <- zoo::rollapply(x.padded, 7, weighSamples, wts = wincoeff)
multiplier <- c((rep(0, padZeros)), (rep(1, length(varBW0))), (rep(0, padZeros)))
weigh.sum <- zoo::rollapply(multiplier, 7, weighSamples, wts = wincoeff)
varBW <- x.weighed/weigh.sum

Norm.Var.dB <- normalise(convertTodB(varBW))
```

The normalised variance



The segmented region



What's next?

- Extract relevant features from the segmented signals.
- Build statistical models for the classification of the physiological activity for diagnostic applications.

Acknowledgement

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