Sunspot Periodicity

Introduction

This application will find the periodicity of sunspots with two separate approaches:

- A frequency domain transformation of the data
- Using autocorrelation

Both approaches yield the same result.

```
> with(SignalProcessing):
  with(plots):
```

Import International Sunspot Number from Internet

Data source:

SIDC-team, World Data Center for the Sunspot Index, Royal Observatory of Belgium, Monthly Report on the International Sunspot Number, online catalogue of the sunspot index (http://sidc.oma.be/sunspot-data/SIDCpub.php)

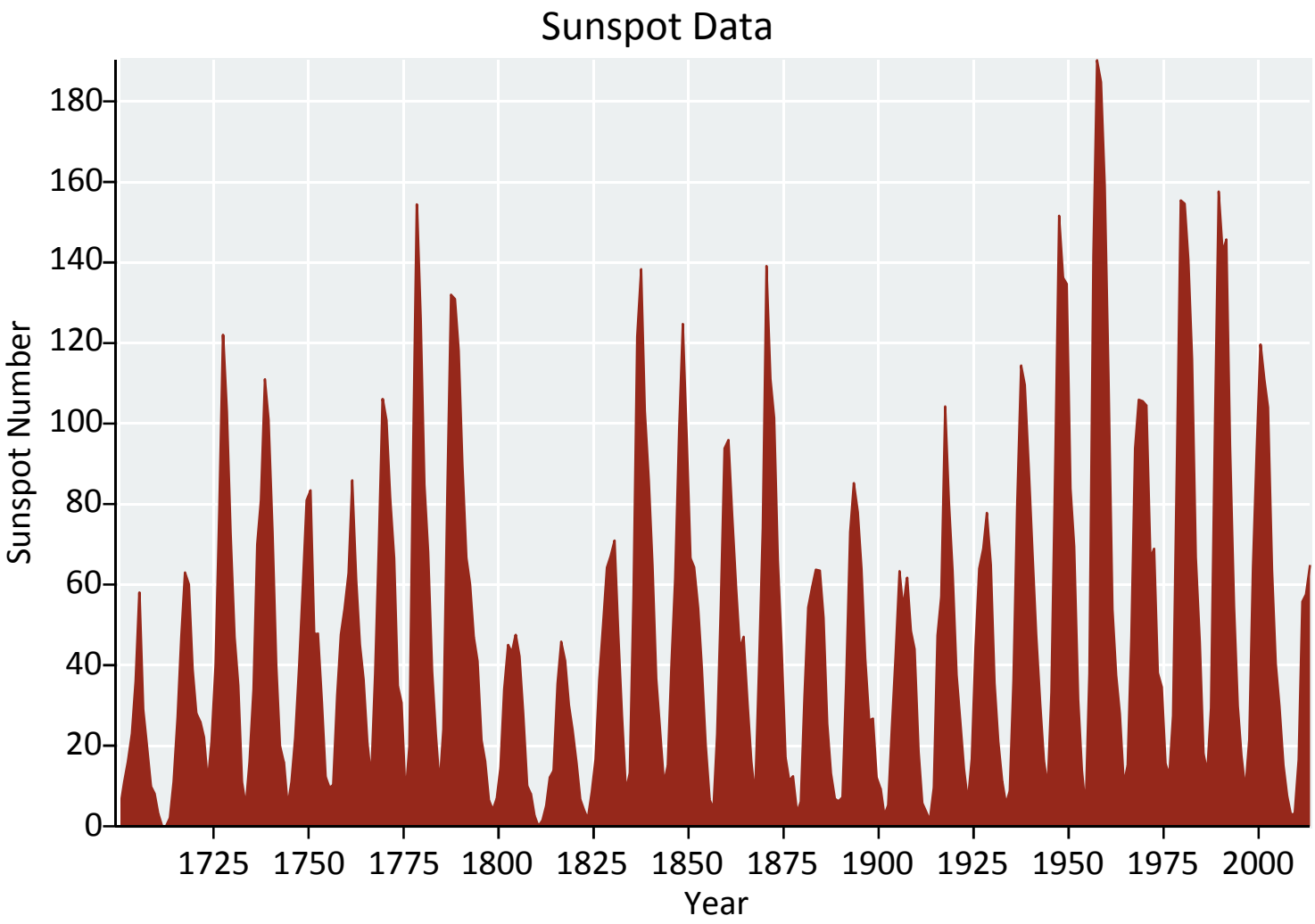
```
> data := ImportMatrix("http://sidc.oma.be/silso/DATA/yearssn.dat", delimiter = " ")
```

$$\mathrm{data} := \begin{bmatrix} 315 \text{ x } 2 \text{ Matrix} \\ \text{Data Type: float}_8 \\ \text{Storage: rectangular} \\ \text{Order: Fortran\_order} \end{bmatrix} \quad \textbf{(2.1}$$

Plot the Data

```
> SunspotNumber := data[..,2]:
> Year := data[..,1]:
> plot([seq([Year[i], SunspotNumber[i]], i = 1..314)], labels = ["Year", "Sunspot Number"], labeldirections = [horizontal,
  vertical], title = "Sunspot Data", titlefont = [Calibri, 14], thickness = 0, filled = true, size = [800, 400], axesfont
  = [Calibri], labelfont = [Calibri], color = RGB(150/255, 40/255, 27/255), transparency = 0, background = ColorTools:-
```

$$\text{Color}\left(\text{"RGB"}, \left[\frac{236}{255}, \frac{240}{255}, \frac{241}{255}\right]\right), \text{axis} = [\text{gridlines} = [10, \text{color} = \text{RGB}(1, 1, 1)]]\Bigg)$$



Periodicity via Fourier Transformation to the Frequency Domain

Now, calculate the period using a Fast Fourier Transform (FFT) of the first 2^8 data points:

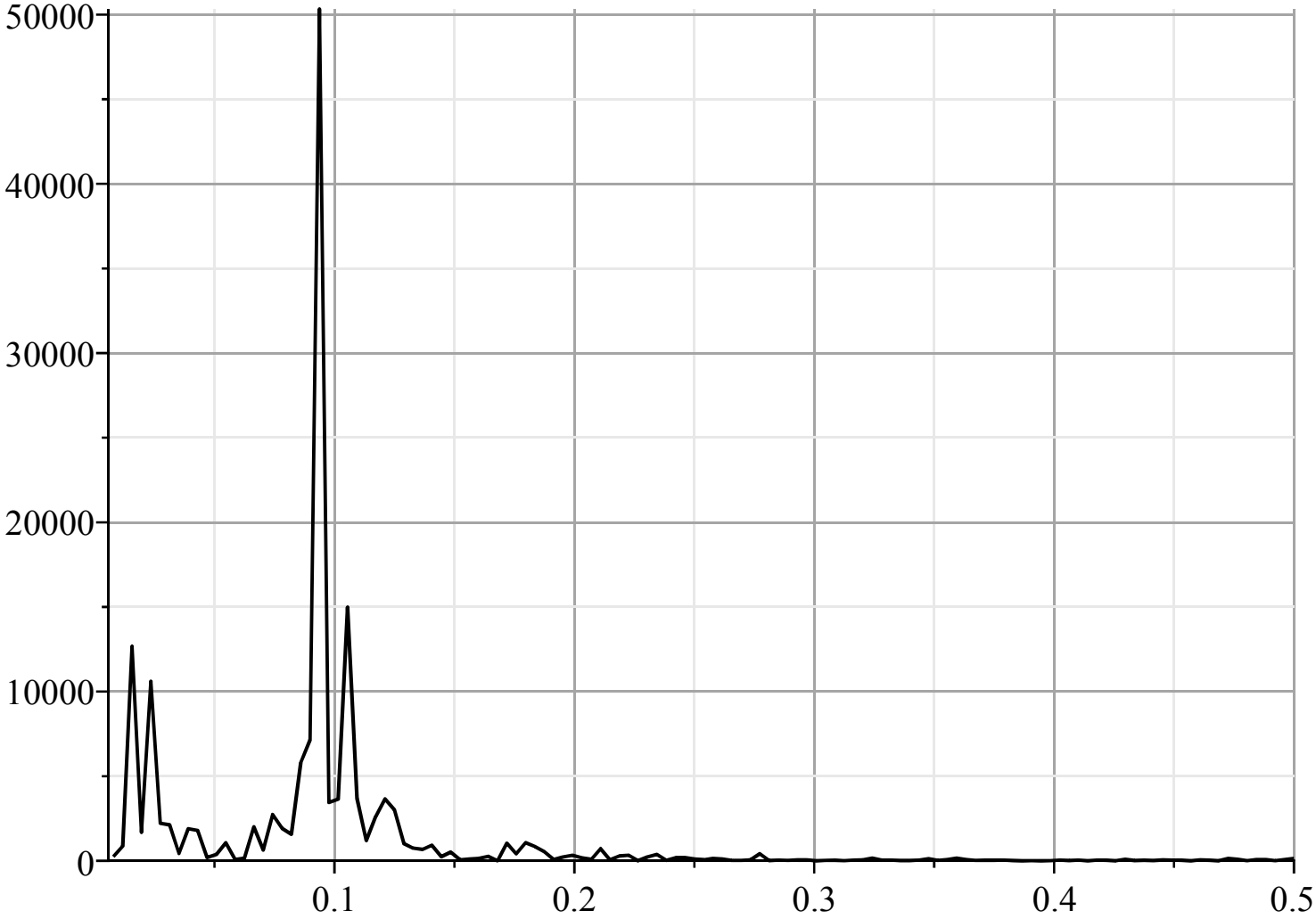
> fSunspots := FFT(SunspotNumber[1..2^8]) :

Plot the power spectrum:

> samplingRate := 1 :

> psSunspots := PowerSpectrum(fSunspots) :

> plots:-pointplot$\left(\left[\text{seq}\left(\left[\frac{i \cdot \text{samplingRate}}{2^8}, \text{psSunspots}[i]\right], i = 2 .. \frac{2^8}{2}\right)\right], \text{connect} = \text{true}, \text{gridlines}\right)$



Note the peak at a frequency of 0.09 years^{-1} . Try zooming in and using the point probe to confirm the value of this peak frequency.

The period is the reciprocal of the peak frequency.

> period := $\frac{1}{0.09}$

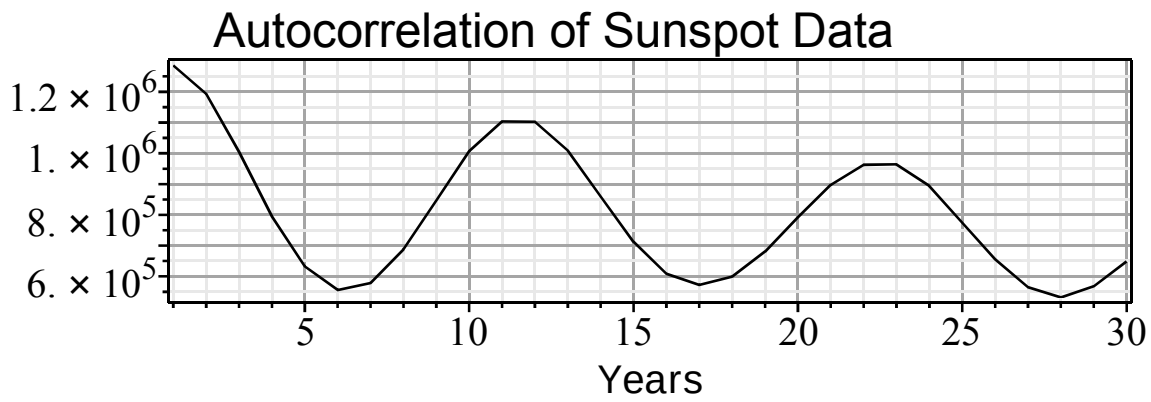
period := 11.11111111 **(4.1**

Hence, the predicted periodicity is approximately 11 years.

Periodicity via Autocorrelation

> aSunspotNumber := AutoCorrelation(SunspotNumber) :

> SignalPlot(aSunspotNumber[1 ..30], labels = ["Years", ""], title = "Autocorrelation of Sunspot Data", titlefont = [Arial, 14]);



Here the first peak is at 11 years, indicating that the periodicity of sunspots is approximately 11 years. This confirms the period predicted by the Fourier Transform approach.