# 数字信号处理B

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## HW1

### Exercise 1

$$
\begin{aligned}
x(nT_s) &= e^{-nT_s}, \quad n = 0, 1, \dots \\
r_x(mT_s) &= \sum_{n=0}^{\infty} x(nT_s)x((n+m)T_s) \\
&= \sum_{n=0}^{\infty} e^{-(2n+m)T_s} \\
&= e^{mT_s} \sum_{n=0}^{\infty} e^{-2nT_s} \\
&= \frac{e^{mT_s}}{1 - e^{-2T_s}}
\end{aligned}
$$

### Exercise 2

#### 性质1

$$
\begin{aligned}
r_x(-m) &= \sum_{n=-\infty}^{\infty} x(n)x(n-m) \\
&= \sum_{n=-\infty}^{\infty} x(n+m)x(n) \\
&= \sum_{n=-\infty}^{\infty} x(n)x(n+m) \\
&= r_x(m)
\end{aligned}
$$

#### 性质2

$$
\begin{aligned}
r_x^*(-m) &= \left( \sum_{n=-\infty}^{\infty} x^*(n)x(n-m) \right)^* \\
&= \sum_{n=-\infty}^{\infty} x(n)x^*(n-m) \\
&= \sum_{n=-\infty}^{\infty} x(n+m)x^*(n) \\
&= \sum_{n=-\infty}^{\infty} x^*(n)x(n+m) \\
&= r_x(m)
\end{aligned}
$$

## Exercise 3

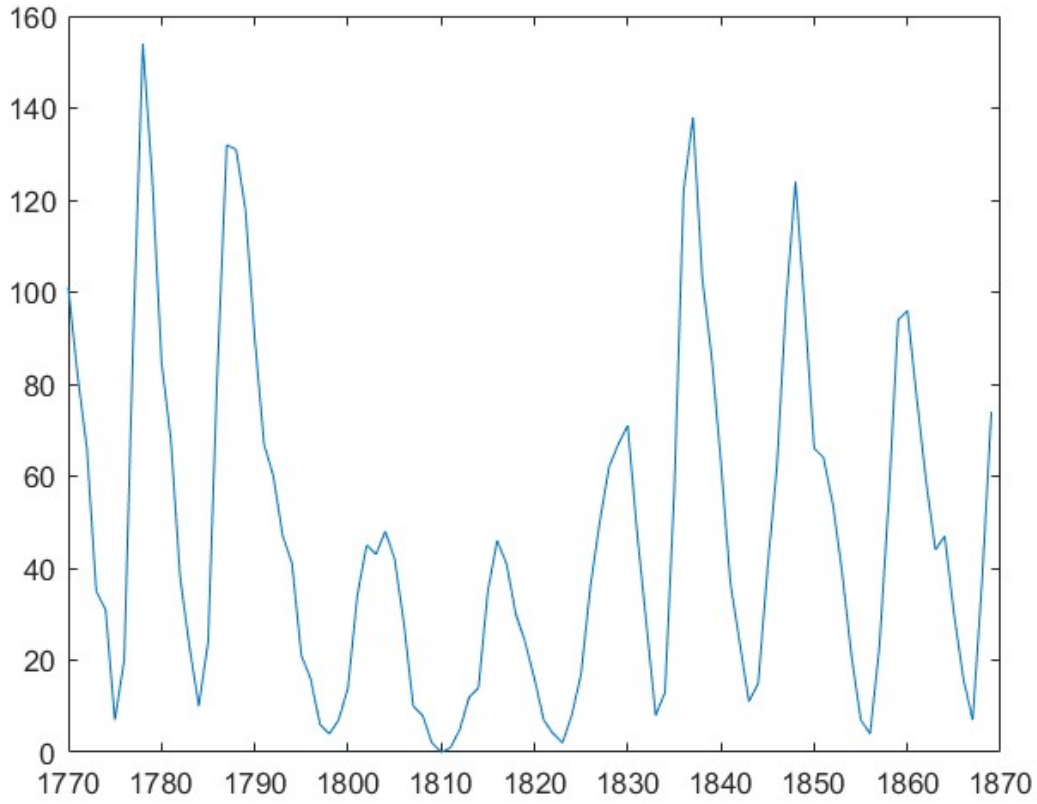
$$x(n) = A_1\cos(2\pi f_1 n T_s) + A_2\sin(2\pi f_2 n T_s)$$

$$\begin{aligned}
r_x(m) &= \sum_{<T>}[A_1\cos(2\pi f_1 n T_s) + A_2\sin(2\pi f_2 n T_s)]\cdot[A_1\cos(2\pi f_1 (n+m) T_s) + A_2\sin(2\pi f_2 (n+m) T_s)] \\
&= \sum_{<T>} A_1^2 cos(2\pi f_1 n T_s)\cos(2\pi f_1 (n+m) T_s) + A_1 A_2\cos(2\pi f_1 n T_s)\sin(2\pi f_2 (n+m) T_s) \\
&\quad + A_1 A_2\sin(2\pi f_2 n T_s)\cos(2\pi f_1 (n+m) T_s) + A_2^2\sin(2\pi f_2 n T_s)\sin(2\pi f_2 (n+m) T_s) \\
&= \sum_{<T>} \frac{A_1^2}{2}[\cos(2\pi f_1 (2n+m) T_s) + \cos(2\pi f_1 m T_s)] \\
&\quad + \frac{A_1 A_2}{2}[\sin(2\pi f_1 (2n+m) T_s) - \sin(2\pi (f_1 n - f_2 n - f_2 m) T_s)] \\
&\quad + \frac{A_1 A_2}{2}[\sin(2\pi (f_2 n + f_1 n + f_1 m) T_s) + \sin(2\pi (f_2 n - f_1 n - f_1 m) T_s)] \\
&\quad + \frac{A_2^2}{2}[\cos(2\pi f_2 m T_s) - \cos(2\pi (f_1 n + f_2 n + f_2 m) T_s)] \\
&= \sum_{<T>} \frac{A_1^2}{2}\cos(2\pi f_1 m T_s) + \frac{A_2^2}{2}\cos(2\pi f_2 m T_s) \\
&= \frac{A_1^2}{2}\cos(2\pi f_1 m T_s) + \frac{A_2^2}{2}\cos(2\pi f_2 m T_s)
\end{aligned}$$

## Exercise 4

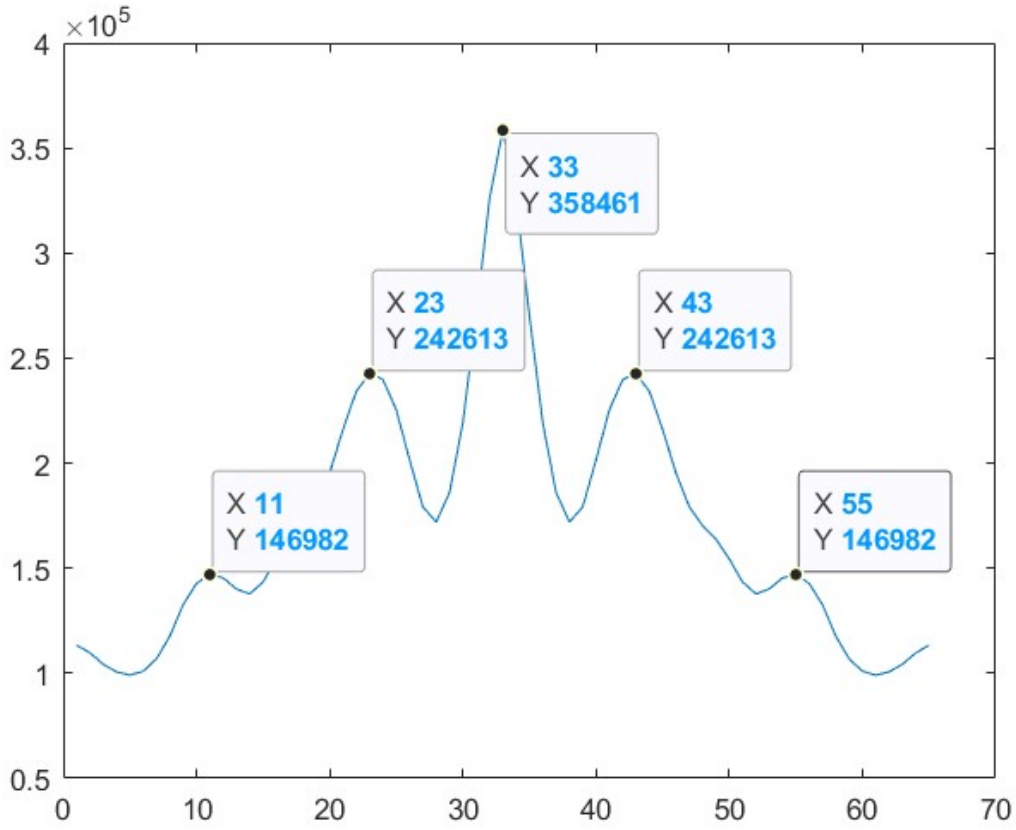
### (1)

太阳黑子图像：



**(2)**

根据相关函数图可以得出，太阳黑子的周期为11年




**(3)**

蓝线为原相关函数，红线为新相关函数，可以看出：减去平均值，相关函数整体往下平移，但是形状不变