

# Time Series (732A62) Lab1

*Anubhav Dikshit(anudi287) and Maximilian Pfundstein(maxpf364)*

*05 September, 2019*

## Contents

Assignment 1. Computations with simulated data	2
Appendix	5

## Assignment 1. Computations with simulated data

a) Generate two time series  $x_t = -0.8x_{t-2} + w_t$ , where  $x_0 = x_1 = 0$  and  $x_t = \cos(\frac{2\pi t}{5})$  with 100 observations each. Apply a smoothing filter  $v_t = 0.2(x_t + x_{t-1} + x_{t-2} + x_{t-3} + x_{t-4})$  to these two series and compare how the filter has affected them.

```
set.seed(12345)

n = 100
x <- vector(length = n)
x2 <- vector(length = n)

x[1] <- 0
x[2] <- 0

#first series generation
for(i in 3:n){
  x[i] <- -0.8 * x[i-2] + rnorm(1,0,1)
}

#second series generation
for(i in 1:n){
  x2[i] <- cos(0.4*pi*i)
}

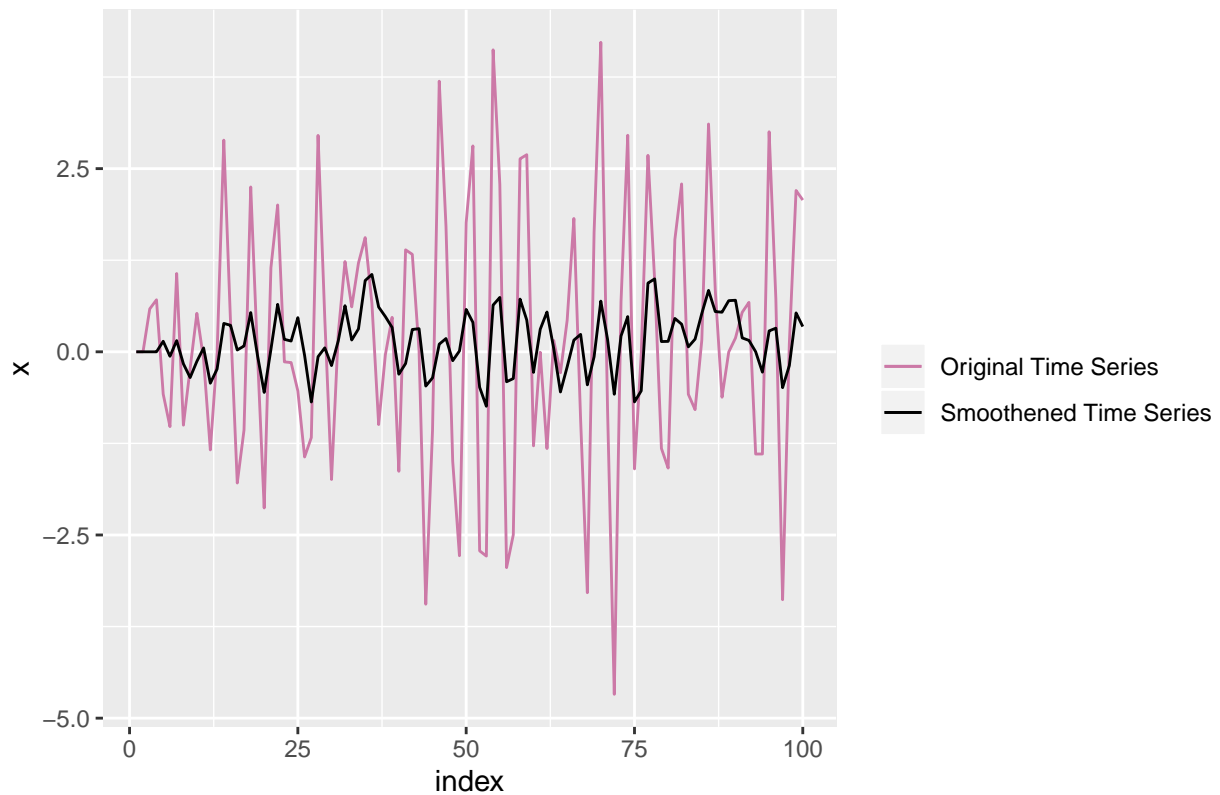
# smoothing filter function
smoothing_filter <- function(x){
  v <- vector(length = length(x))
  for(i in 5:length(x)){
    v[i] = 0.2 * (x[i] + x[i-1] + x[i-2] + x[i-3] + x[i-4])
  }
  return(v)
}

#generate smoothed series
smooth_x <- smoothing_filter(x)
smooth_x2 <- smoothing_filter(x2)

#adding everything to a dataframe
df <- cbind(x,x2,smooth_x,smooth_x2) %>% as.data.frame() %>% mutate(index=1:100)

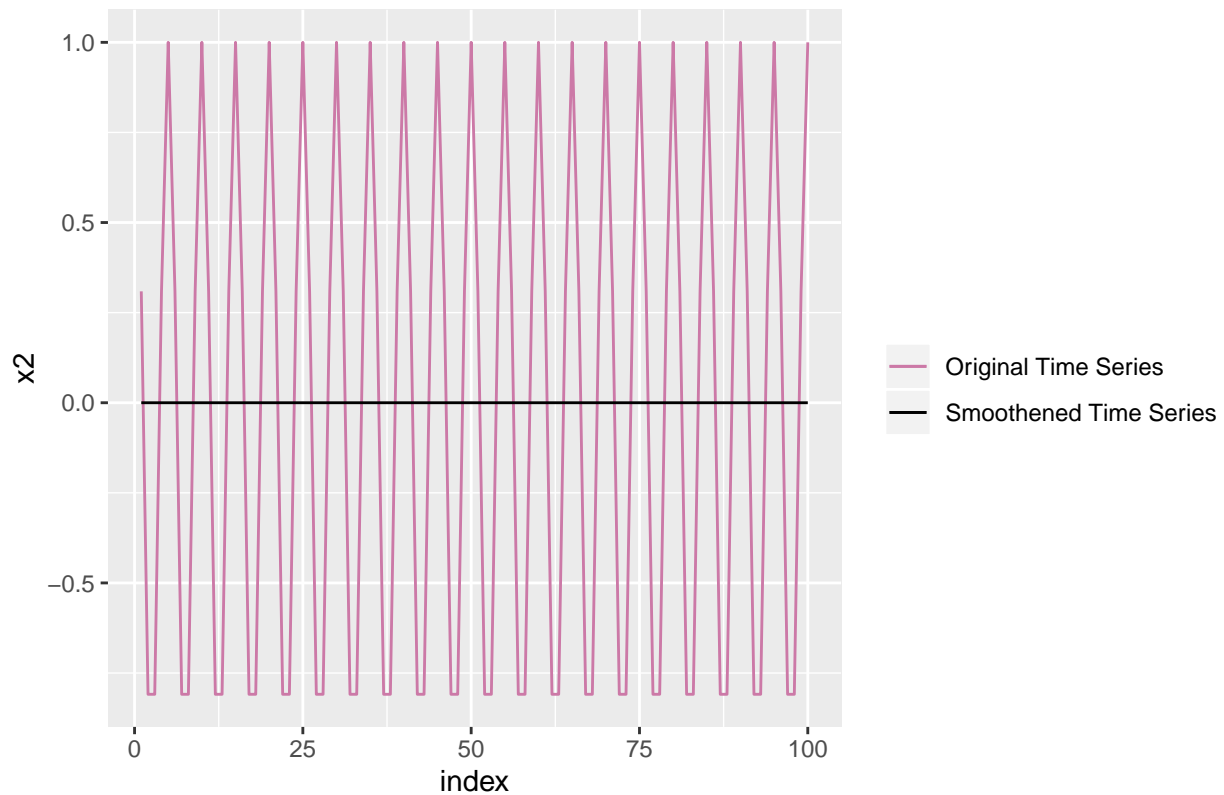
ggplot(df, aes(x=index)) +
  geom_line(aes(y=x, color="Original Time Series")) +
  geom_line(aes(y=smooth_x, color="Smoothened Time Series")) +
  ggtitle("Plot of 1st time series and its smoothened version") +
  scale_colour_manual("", breaks = c("Original Time Series", "Smoothened Time Series"),
    values = c("#CC79A7", "#000000"))
```

Plot of 1st time series and its smoothed version



```
ggplot(df, aes(x=index)) +  
  geom_line(aes(y=x2, color="Original Time Series")) +  
  geom_line(aes(y=smooth_x2, color="Smoothed Time Series")) +  
  ggtitle("Plot of 2nd time series and its smoothed version") +  
  scale_colour_manual("", breaks = c("Original Time Series", "Smoothed Time Series"),  
    values = c("#CC79A7", "#000000"))
```

Plot of 2nd time series and its smoothened version



b) Consider time series  $x_t - 4x_{t-1} + 2x_{t-2} + x_{t-5} = w_t + 3w_{t-2} + w_{t-4} - 4w_{t-6}$ . Write an appropriate R code to investigate whether this time series is casual and invertible.

A linear process  $X_t$  is causal (strictly, a causal function of  $w_t$ ) if there is a

$$\psi(B) = \psi_0 + \psi_1 B + \psi_2 B^2 + \dots$$

with

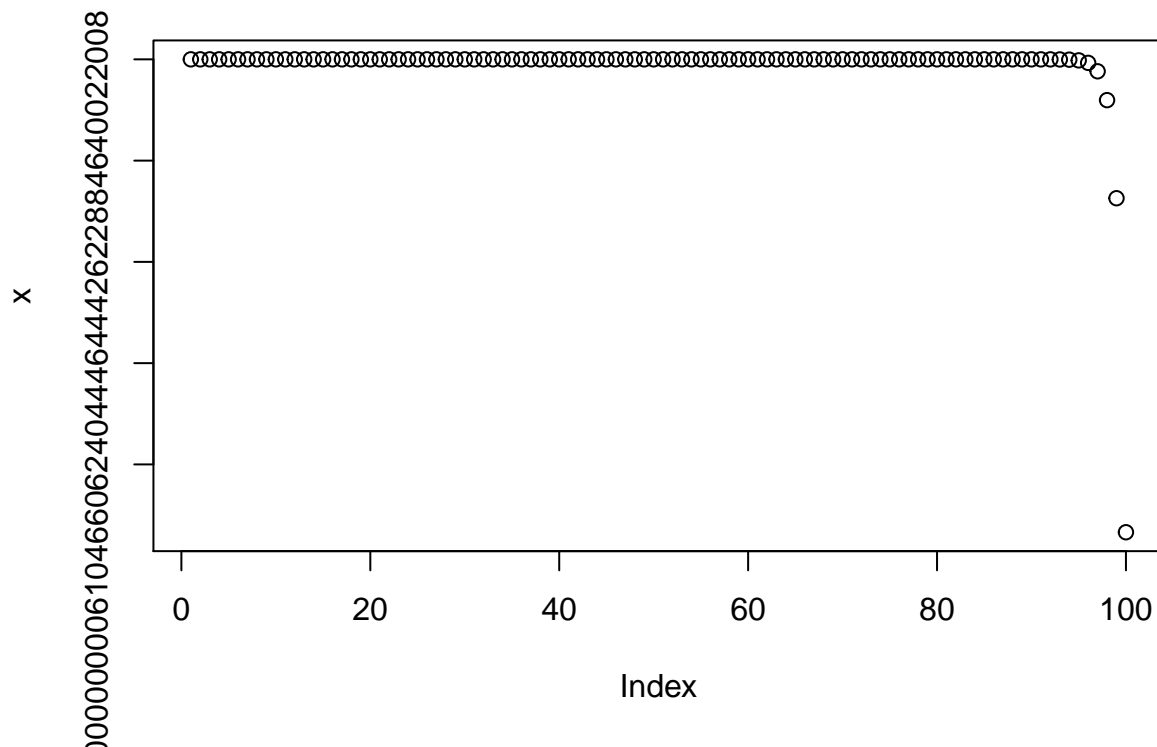
$$\sum_{j=0}^{\infty} |\psi_j| < \infty$$

and

$$X_t = \psi(B)w_t$$

```
set.seed(12345)
w <- rnorm(100,0,1)
x <- rep(0,100)

for(i in 7:100){
  x[i] = w[i] + 3 * w[i-2] + w[i-4] - 4 * w[i-6] + 4 * x[i-1] - 2 * x[i-2] - x[i-5]
}
plot(x)
```



c) Use built-in R functions to simulate 100 observations from the process  $x_t + \frac{3}{4}x_{t-1} = w_t - \frac{1}{9}w_{t-2}$ , compute sample ACF and theoretical ACF, use seed 54321. Compare the ACF plots.

```
set.seed(54321)
```

## Appendix

```
knitr::opts_chunk$set(echo = TRUE)
options(scipen=999)

library("ggplot2")
library("tidyverse")
library("gridExtra") # combine plots
library("knitr")

# The palette with black:
cbbPalette <- c("#000000", "#E69F00", "#56B4E9", "#009E73",
               "#F0E442", "#0072B2", "#D55E00", "#CC79A7")
set.seed(12345)
set.seed(12345)

n = 100
```

```

x <- vector(length = n)
x2 <- vector(length = n)

x[1] <- 0
x[2] <- 0

#first series generation
for(i in 3:n){
  x[i] <- -0.8 * x[i-2] + rnorm(1,0,1)
}

#second series generation
for(i in 1:n){
  x2[i] <- cos(0.4*pi*i)
}

# smoothing filter function
smoothing_filter <- function(x){
  v <- vector(length = length(x))
  for(i in 5:length(x)){
    v[i] = 0.2 * (x[i] + x[i-1] + x[i-2] + x[i-3] + x[i-4])
  }
  return(v)
}

#generate smoothed series
smooth_x <- smoothing_filter(x)
smooth_x2 <- smoothing_filter(x2)

#adding everything to a dataframe
df <- cbind(x,x2,smooth_x,smooth_x2) %>% as.data.frame() %>% mutate(index=1:100)

ggplot(df, aes(x=index)) +
  geom_line(aes(y=x, color="Original Time Series")) +
  geom_line(aes(y=smooth_x, color="Smoothened Time Series")) +
  ggtitle("Plot of 1st time series and its smoothened version") +
  scale_colour_manual("", breaks = c("Original Time Series", "Smoothened Time Series"),
    values = c("#CC79A7", "#000000"))

ggplot(df, aes(x=index)) +
  geom_line(aes(y=x2, color="Original Time Series")) +
  geom_line(aes(y=smooth_x2, color="Smoothened Time Series")) +
  ggtitle("Plot of 2nd time series and its smoothened version") +
  scale_colour_manual("", breaks = c("Original Time Series", "Smoothened Time Series"),
    values = c("#CC79A7", "#000000"))

set.seed(12345)
w <- rnorm(100,0,1)
x <- rep(0,100)

for(i in 7:100){
  x[i] = w[i] + 3 * w[i-2] + w[i-4] - 4 * w[i-6] + 4 * x[i-1] - 2 * x[i-2] - x[i-5]
}

```

```
plot(x)  
set.seed(54321)
```