P8106_HW2

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Contents

Loading libraries

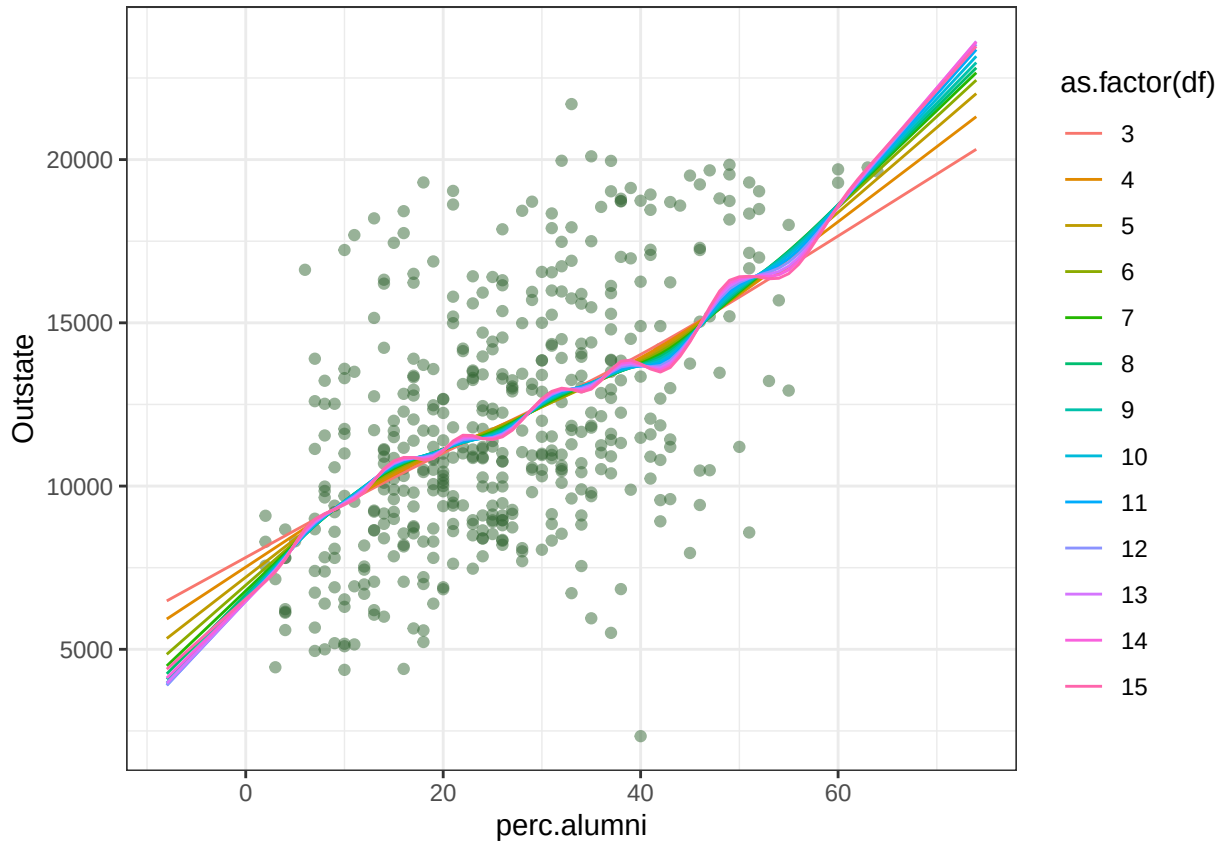
```
library(tidyverse)
library(ISLR)
library(pls)
library(caret)
library(tidymodels)
```

Partition into training and testing set

```
# Read in dataset
college <- read.csv("College.csv")

# Remove NAs
college <- na.omit(college)

# Set seed for reproducibility
set.seed(299)

# Split data into training and testing data
data_split <- initial_split(college, prop = 0.8)


# Extract the training and test data
training_data <- training(data_split)
testing_data <- testing(data_split)
```

Question (a): Smoothing spline models

```r
# Set seed for reproducibility
set.seed(299)

# Fit smoothing spline
fit.ss <- smooth.spline(training_data$perc.alumni, training_data$Outstate)

# Define a grid for smooth predictions using dataset range
# Will illustrate curves beyond dataset boundary
perc.alumni.grid <- seq(from = min(training_data$perc.alumni) - 10,
                        to = max(training_data$perc.alumni) + 10,
                        by = 1)

# Create dataframe of degrees of freedom range
df_values <- seq(3, 15, by = 1)

# Create dataframe to store smoothing spline predictions
ss.predictions <- data.frame()

# Use for loop to populate ss.predictions dataframe
# Code Source: https://www.rdocumentation.org/packages/openintro/versions/2.4.0/topics/loop

for (df in df_values) {

  # Plot smoothing spline curves for different degrees of freedom
  # Code Source: https://www.rdocumentation.org/packages/stats/versions/3.6.2/topics/smooth.spline

  fit <- smooth.spline(training_data$perc.alumni, training_data$Outstate, df = df)
  pred <- predict(fit, x = perc.alumni.grid)

  # Store pred for current df
  temp_df <- data.frame(
    perc.alumni = perc.alumni.grid,
    pred = pred$y,
    df = df
  )

  ss.predictions <- rbind(ss.predictions, temp_df) # Add to ss.predictions
}

# Scatter plot of perc.alumni vs Outstate
ss.p <- ggplot(training_data, aes(x = perc.alumni, y = Outstate)) +
  geom_point(color = rgb(.2, .4, .2, .5))

# Add smoothing spline curves for df range 3-15
ss.p +
  geom_line(aes(x = perc.alumni, y = pred, color = as.factor(df)),
          data = ss.predictions) + theme_bw()
```



The plot I produced represents the fitted smoothing spline curves for each degree of freedom between the range of 3 and 15. It can be observed that as the degrees of freedom increases over this range, the smoothing spline goes from underfitting, to overfitting of the data. Specifically, as the degrees of freedom increases beyond ~10, the spline curve becomes highly wiggly, particularly at extreme values of perc.alumni, indicating overfitting of the data. However, for lower df (i.e., 3–5), the spline appears too smooth and does not capture much variation in the data.

```
# Set seed for reproducibility
set.seed(299)

fit.ss.gcv <- smooth.spline(training_data$perc.alumni, training_data$Outstate)

gcv_df <- fit.ss.gcv$df  # Extract optimal df selected by GCV
print(gcv_df) # 2.000237 appears to be the optimal df selected by GCV
```

```
## [1] 2.000237
```

```
# Predict values using GCV-selected df
pred.ss.gcv <- predict(fit.ss.gcv, x = perc.alumni.grid)

# Convert predictions to dataframe
ss.optimal <- data.frame(
  perc.alumni = perc.alumni.grid,
  pred = pred.ss.gcv$y
)
```

```
# Add optimal spline curve to the plot

ss.p +
  geom_line(aes(x = perc.alumni, y = pred), data = ss.optimal,
  color = rgb(.8, .1, .1, 1), size = 1) + theme_bw()
```