

# Assignment 04 - STAT 689

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```
# Import third-party modules  
library("mgcv")
```

Import our data and take a look:

```
fossil <- read.csv("C:/Users/Philip/Schools/TAMU/STAT_689/homework/semiparametric-regression/misc/fossil.csv")  
names(fossil) <- tolower(names(fossil))  
head(fossil)
```

```
##      age strontium.ratio  
## 1 91.78525      0.707343  
## 2 91.78525      0.707359  
## 3 92.39579      0.707410  
## 4 93.97061      0.707438  
## 5 95.57577      0.707463  
## 6 95.60286      0.707320
```

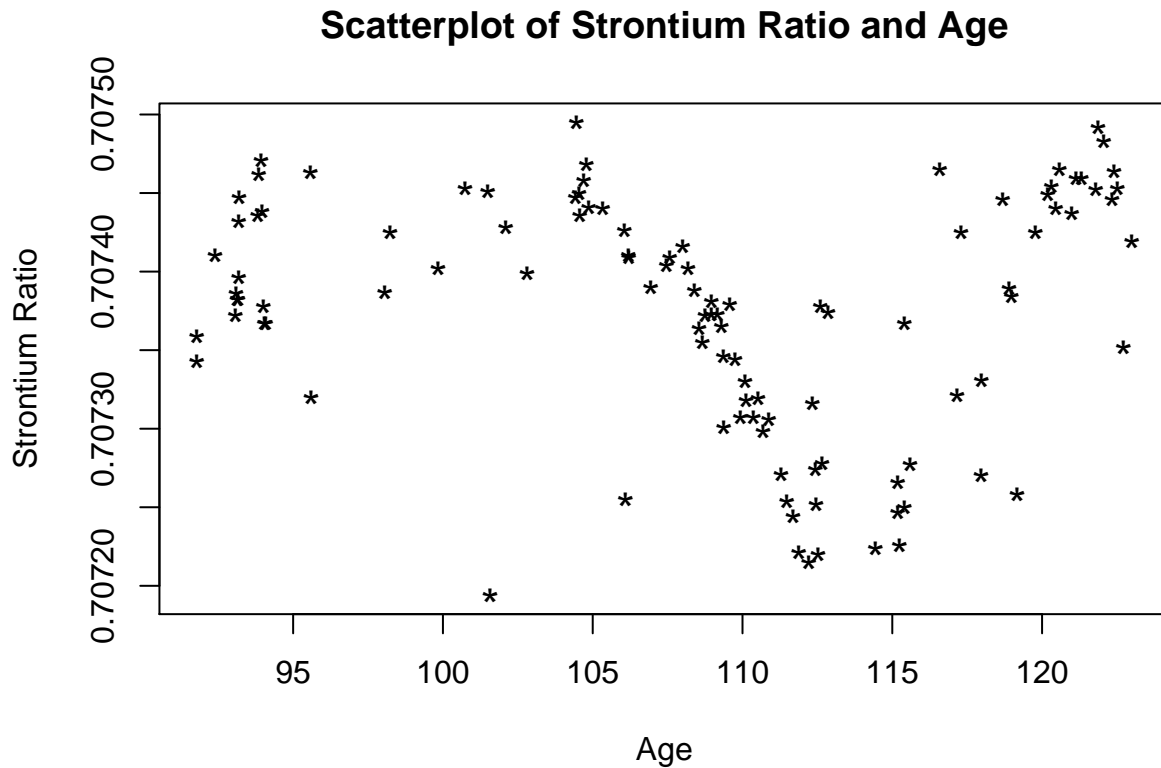
```
summary(fossil)
```

```
##      age      strontium.ratio  
## Min.   : 91.79   Min.      :0.7072  
## 1st Qu.:103.62   1st Qu.:0.7073  
## Median :109.37   Median :0.7074  
## Mean   :108.62   Mean    :0.7074  
## 3rd Qu.:115.41   3rd Qu.:0.7074  
## Max.   :123.00   Max.     :0.7075
```

## Question 1

Display a scatterplot of the data and comment on which features appear interesting.

```
# non-generalizable function for this data/plot only  
fossil_plotter <- function() {  
  plot(fossil$age, fossil$strontium.ratio, pch="*", cex=1.5  
        , main="Scatterplot of Strontium Ratio and Age"  
        , xlab="Age"  
        , ylab="Strontium Ratio"  
        )  
}  
  
fossil_plotter()
```



The features of this data that appear most interesting are:

- The clear non-linear relationship between age and Strontium ratio.
- Some evidence of heteroscedasticity
- Strontium ratio appears to have a higher variance at lower values of age.
- The necessity for a three-part piecewise regression, with a positive line from 90-105, negative from 105-112.5, and positive again from 112.5 to 125.

## Question 2

### Question 2a

Fit the fossil data using the default version of `stats::smooth.spline`

```
myspline <- stats::smooth.spline(x=fossil$age, y=fossil$strontium.ratio)
myspline

## Call:
## stats::smooth.spline(x = fossil$age, y = fossil$strontium.ratio)
##
## Smoothing Parameter spar= 0.7240878 lambda= 1.216781e-05 (12 iterations)
## Equivalent Degrees of Freedom (Df): 18.38485
## Penalized Criterion (RSS): 1.992173e-07
## GCV: 2.716276e-09
```

## Question 2B

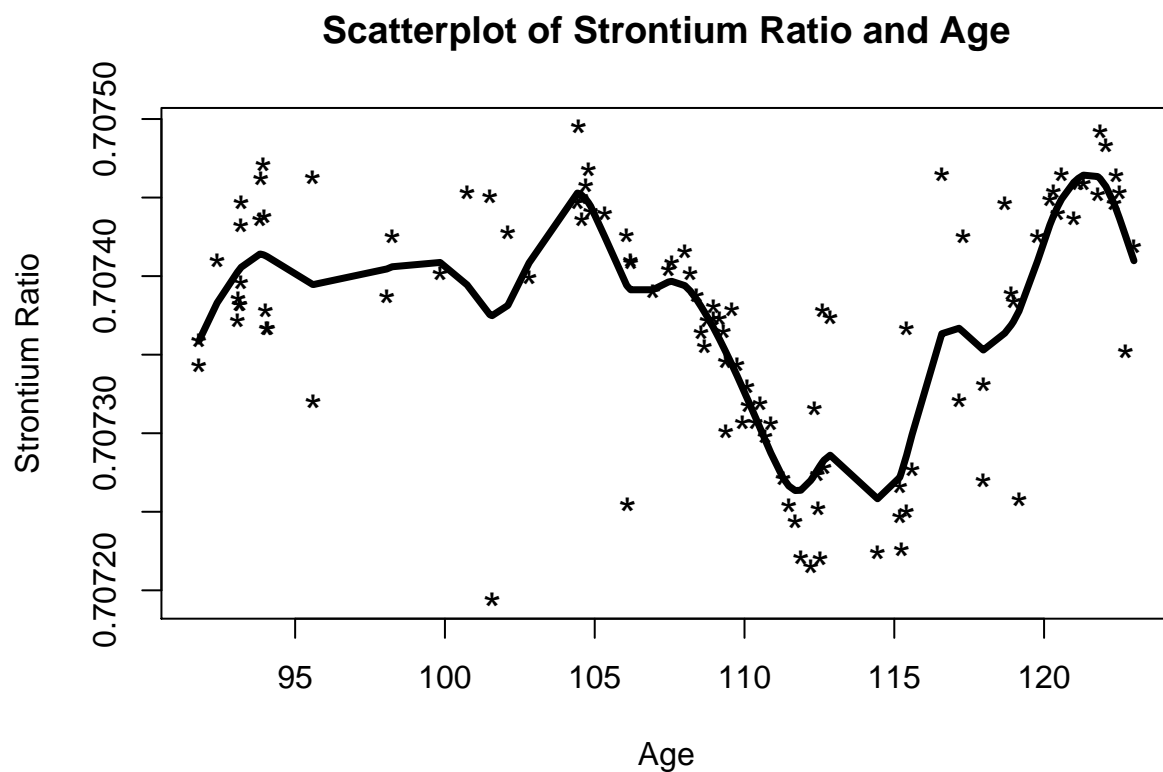
Is the fit statistically significant?

Skip question

## Question 2C

Add the fit to the scatterplot

```
fossil_plotter()  
lines(myspline, lwd=3.5)
```



## Question 3

Run the mgcv fit to the data with the default number of knots (8), along with 4 and 23 using the cubic spline option.

Using a simple function to save space.

```
fossil_gam <- function(knots=8) {  
  gam_mod <- mgcv::gam(strontium.ratio ~ s(age, k=knots, bs="cr")  
    , data=fossil  
  )  
  return(gam_mod)
```

```

}

gam8 <- fossil_gam(knots=8)
gam4 <- fossil_gam(knots=4)
gam23 <- fossil_gam(knots=23)

```

### Question 3a

Which fits are statistically significant?

I am using `gam.check(.)` to arrive at these values. I am not displaying the `gam.check(.)` output, as it renders many plots, and the plotting functionality does not appear to be disable-able. It is also not clear from the `gam.check` source code how to just extract p-values.

```

paste0("GAM with 8 knots spline p-value: 0.46")

## [1] "GAM with 8 knots spline p-value: 0.46"
paste0("GAM with 4 knots spline p-value: 0.08")

## [1] "GAM with 4 knots spline p-value: 0.08"
paste0("GAM with 23 knots spline p-value: 0.97")

## [1] "GAM with 23 knots spline p-value: 0.97"

```

Only the GAM fit with 4 knots has a statistically significant slope.

### Question 3b

Plot the data points on one graph only.

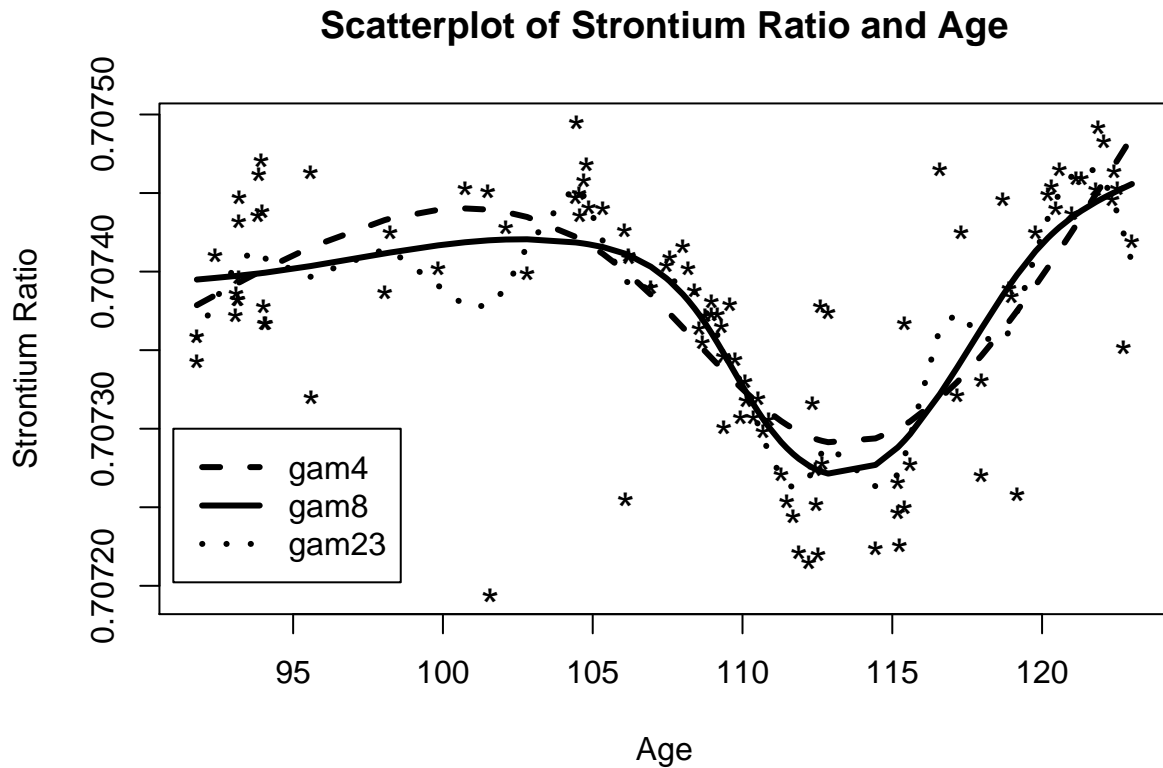
```

# point ordering for plots
age_ord <- order(fossil$age)

# initiate plots
fossil_plotter()
lines(fossil$age[age_ord], gam8$fitted.values[age_ord], lty=1, lwd=3)
lines(fossil$age[age_ord], gam4$fitted.values[age_ord], lty=2, lwd=3)
lines(fossil$age[age_ord], gam23$fitted.values[age_ord], lty=3, lwd=3)

legend(91, 0.7073
      , c("gam4", "gam8", "gam23")
      , lty=c(2, 1, 3)
      , lwd= rep(3,3)
      )

```



### Question 3c

The fits from all gam models are consistent with my initial observation of non-linearity. The smoothing parameters for all fits also break the regression into three main pieces, with an ascending piece followed by a descending piece, again followed by an ascending piece.

### Question 4

What are the effective degrees of freedom for each mgcv fit?

```
paste0("GAM with 8 knots edf: ", sum(gam8$edf) - 1) # subtract 1 for one predictor model

## [1] "GAM with 8 knots edf: 5.99019961739269"

paste0("GAM with 4 knots edf: ", sum(gam4$edf) - 1)

## [1] "GAM with 4 knots edf: 2.98781801014555"

paste0("GAM with 23 knots edf: ", sum(gam23$edf) - 1)

## [1] "GAM with 23 knots edf: 15.8526035231863"
```

## Question 5

What is lambda for each fit?

```
paste0("GAM with 8 knots lambda value: " , gam8$sp)
```

```
## [1] "GAM with 8 knots lambda value: 1.59552509993438"
```

```
paste0("GAM with 4 knots lambda value: " , gam4$sp)
```

```
## [1] "GAM with 4 knots lambda value: 0.0990383701373478"
```

```
paste0("GAM with 23 knots lambda value: " , gam23$sp)
```

```
## [1] "GAM with 23 knots lambda value: 1.19545806847315"
```

## Question 6

Are any of the p-values less than 0.10?

With a p-value of 0.08, only the GAM with 4 knots has an inadequate fit. This is likely because the data displays a number of small trend fluctuations that only 4 knots are unable to capture. We can see in the most recent graphic that the GAM with 4 knots is unable to capture a necessary amount of the variation present in our data.