# Assignment 12; STAT 689

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```
library("HRW")
library("mgcv")
library("nlme")
library("lattice")
library("tidyverse")
```

```
# bring in the data
pigs <- read.csv('/Users/panders2/Documents/schools/tamu/stat_689/homework/semiparametric-regression/hw
str(pigs)
```

```
## 'data.frame':    432 obs. of  3 variables:
##  $ id.num   : int  1 1 1 1 1 1 1 1 1 2 ...
##  $ num.weeks: int  1 2 3 4 5 6 7 8 9 1 ...
##  $ weight   : num  24 32 39 42.5 48 54.5 61 65 72 22.5 ...
```

## Question 1

### 1A

How many pigs are in the model?

```
cat('Distinct pigs in the data given by: ', length(unique(pigs$id.num)))
```

```
## Distinct pigs in the data given by:  48
```

### 1B

Fit the random function model and display your code. I am going to model pig weight as a function of the number of weeks since measurement on the pigs began.

```
# extract the important variables into individual objects
id_num <- pigs$id.num
num_weeks <- pigs$num.weeks
pig_weight <- pigs$weight
```

Now, we need to set up the design matrices for the splines at the population (global) level and individual (group) level. Note that the individual level will have fewer knots than the population level.

```
# number records
numObs <- length(id_num)
# number of subjects
numGrp <- length(unique(id_num))

## population (Gbl) work
# knots
numIntKnotsGbl <- 20
# population O-Sull Basis Functions
```

```r
intKnotsGbl <- quantile(unique(num_weeks)
                        , seq(0, 1, length=numIntKnotsGbl+2)
                        )[-c(1, numIntKnotsGbl+2)]
range.num_weeks <- c(min(num_weeks)-0.01, max(num_weeks)+0.01)

Zgbl <- HRW::ZOSull(num_weeks, range.x=range.num_weeks, intKnots=intKnotsGbl)

## subject-level (Grp) work
numIntKnotsGrp <- 10
intKnotsGrp <- quantile(unique(num_weeks)
                        , seq(0, 1, length=numIntKnotsGrp+2)
                        )[-c(1, numIntKnotsGrp+2)]
Zgrp <- HRW::ZOSull(num_weeks, range.x=range.num_weeks, intKnots=intKnotsGrp)
```

Now, set up the random effects structure.

```r
dummyId <- factor(rep(1, numObs))
Zblock <- list(
              dummyId = pdIdent( ~ -1 + Zgbl)
              , id_num = pdSymm(~ num_weeks)
              , id_num = pdIdent(~ -1 + Zgrp)
              )
gd <- groupedData(pig_weight ~ num_weeks|rep(1, length=numObs)
                  , data=data.frame(pig_weight, num_weeks, Zgbl, Zgrp, id_num)
                  )
fit <- lme(pig_weight ~ num_weeks, data=gd, random=Zblock)
```

```
## Warning in lme.formula(pig_weight ~ num_weeks, data = gd, random = Zblock):
## fewer observations than random effects in all level 3 groups
```

## 1C

Display the summary statistics that are mentioned in Lecture 18.

```r
summary(fit)
```

```
## Linear mixed-effects model fit by REML
##  Data: gd
##        AIC      BIC    logLik
##   1646.664 1679.174 -815.3321
##
## Random effects:
##  Formula: ~-1 + Zgbl | dummyId
##  Structure: Multiple of an Identity
##              Zgbl1     Zgbl2     Zgbl3     Zgbl4     Zgbl5     Zgbl6
## StdDev: 0.9017533 0.9017533 0.9017533 0.9017533 0.9017533 0.9017533
##              Zgbl7     Zgbl8     Zgbl9    Zgbl10    Zgbl11    Zgbl12
## StdDev: 0.9017533 0.9017533 0.9017533 0.9017533 0.9017533 0.9017533
##             Zgbl13    Zgbl14    Zgbl15    Zgbl16    Zgbl17    Zgbl18
## StdDev: 0.9017533 0.9017533 0.9017533 0.9017533 0.9017533 0.9017533
##             Zgbl19    Zgbl20    Zgbl21    Zgbl22
## StdDev: 0.9017533 0.9017533 0.9017533 0.9017533
##
##  Formula: ~num_weeks | id_num %in% dummyId
```

```
##  Structure: General positive-definite
##             StdDev    Corr
## (Intercept) 2.6885425 (Intr)
## num_weeks   0.6291173 -0.098
##
##  Formula: ~-1 + Zgrp | id_num %in% id_num %in% dummyId
##  Structure: Multiple of an Identity
##             Zgrp1     Zgrp2     Zgrp3     Zgrp4     Zgrp5     Zgrp6
## StdDev: 0.6421216 0.6421216 0.6421216 0.6421216 0.6421216 0.6421216
##             Zgrp7     Zgrp8     Zgrp9    Zgrp10    Zgrp11    Zgrp12
## StdDev: 0.6421216 0.6421216 0.6421216 0.6421216 0.6421216 0.6421216
##          Residual
## StdDev: 0.8354407
##
## Fixed effects: pig_weight ~ num_weeks
##                 Value Std.Error  DF  t-value p-value
## (Intercept) 19.358295 0.3999824 383 48.39787       0
## num_weeks    6.211238 0.0924196 383 67.20697       0
##  Correlation:
##           (Intr)
## num_weeks -0.133
##
## Standardized Within-Group Residuals:
##          Min           Q1          Med           Q3          Max
## -3.070195309 -0.462303093 -0.002530952  0.433184382  2.479136098
##
## Number of Observations: 432
## Number of Groups:
##                            dummyId               id_num %in% dummyId
##                                  1                                48
## id_num.1 %in% id_num %in% dummyId
##                                 48
```

## Question 2

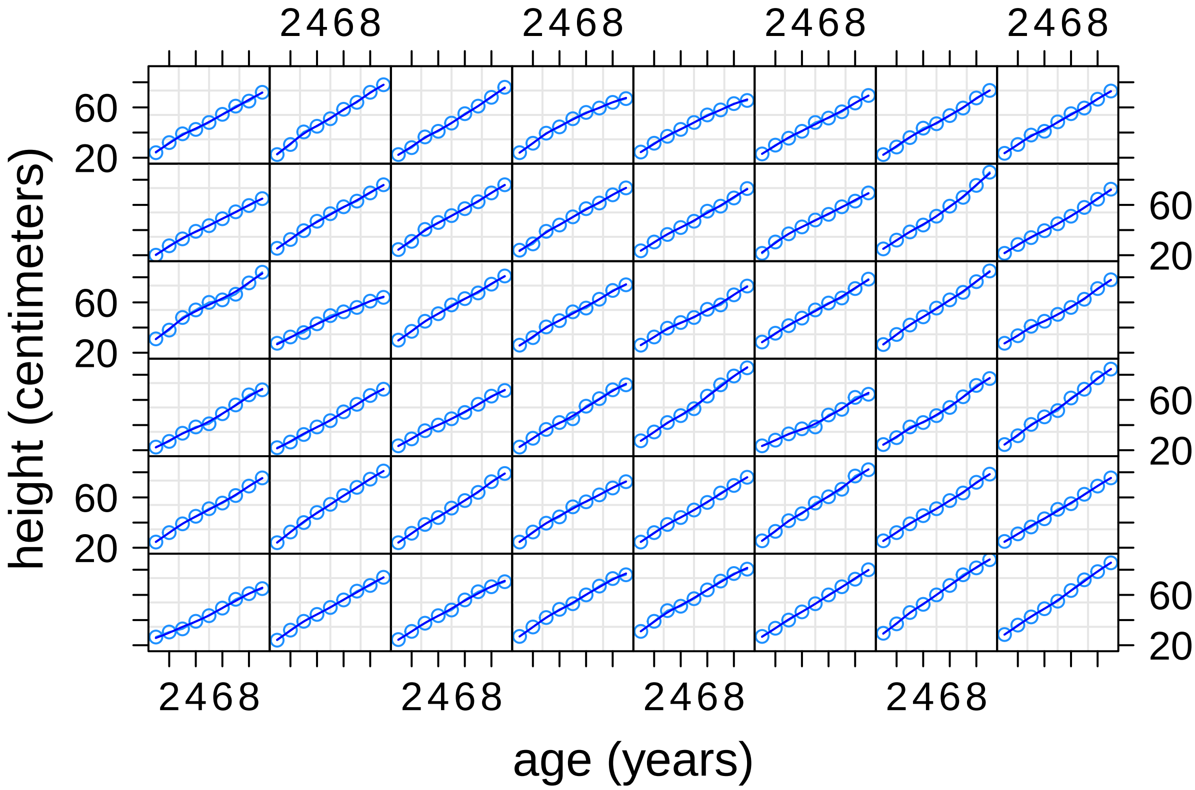
Plot the population-level BLUP estimates.

```r
# number of grid points
ng <- 101
# grid for num_weeks
num_weeks_g <- seq(range.num_weeks[1], range.num_weeks[2], length=ng)
# design matrix for linear component; col of 1's plus num_weeks grid
Xg <- cbind(rep(1, ng), num_weeks_g)

# spline terms - overall fit
Zgblg <- HRW::ZOSull(num_weeks_g, range.x=range.num_weeks, intKnots=intKnotsGbl)
# spline terms for individual fits
Zgrpg <- HRW::ZOSull(num_weeks_g, range.x=range.num_weeks, intKnots=intKnotsGrp)

# grab betaHat, the model intercept, and the slope from our model objet
betaHat <- as.vector(fit$coefficients$fixed)
# grab uHat, along with the estimated spline coef for overall fit
uHat <- as.vector(fit$coefficients$random[[1]])
```

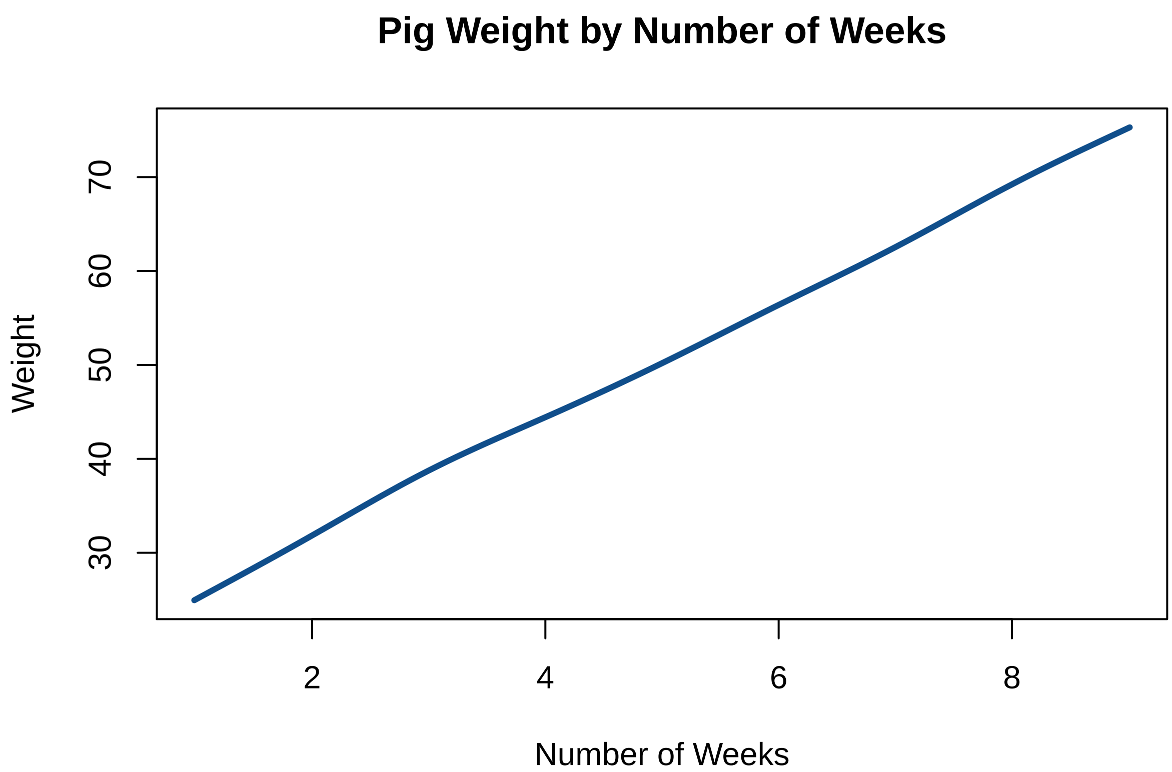
```r
# form the overall fit
fHatg <- as.vector(Xg %*% betaHat + Zgblg %*% uHat)
# subject-specific estimated curves
curvEsts <- vector("list", numGrp)

for (i in 1:numGrp)
  {
  # subject-specific slope + intercept
  uLinHati <- as.vector(fit$coefficients$random[[2]][i, ])
  # subject-specific terms for splines
  uSplHati <- as.vector(fit$coefficients$random[[3]][i, ])
  # individual function estimates
  ghati <- Xg %*% uLinHati + Zgrpg %*% uSplHati
  curvEsts[[i]] <- fHatg + ghati
  }
```

Now, form a lattice plot.

```r
figure <- xyplot(pig_weight ~ num_weeks | id_num
                 , groups=id_num
                 , strip=F
                 , scales=list(cex=1.25)
                 , xlab=list("age (years)", cex=1.5)
                 , ylab=list("height (centimeters)", cex=1.5)
                 , as.table=T
#                 , layout=c(4,7)
                 , panel=function(x, y, subscripts, groups)
                     {
                        panel.grid()
                        adolNum  <- id_num[subscripts][1]
                        panel.superpose(x, y, subscripts, groups
                                        , col="dodgerblue", type="b"
                                        )
                        panel.xyplot(num_weeks_g, curvEsts[[adolNum]]
                                     , col="blue", type="l"
                                     )
                     }
                 )
figure
```




```r
plot(num_weeks_g, fHatg, type="l", col="dodgerblue4", lwd=3
     , xlab="Number of Weeks"
     , ylab="Weight"
     , main="Pig Weight by Number of Weeks"
     )
```




## Question 4

Rerun problem 1 for separate time periods, first weeks 1-5, and then for weeks 6-9.

```
# first split out the data
pigs_epoch_1 <- pigs %>%
  dplyr::filter(num_weeks < 6)
pigs_epoch_2 <- pigs %>%
  dplyr::filter(num_weeks >= 6)
```

I am going to work with the first time period first. Because a lot of this code is recycled from above, I will have reduced comments.

```
# extract meaningful variables into objects
id_num <- pigs_epoch_1$id.num
num_weeks <- pigs_epoch_1$num.weeks
pig_weight <- pigs_epoch_1$weight
```

```
# set up our design matrices.
# number records
numObs <- length(id_num)
# number of subjects
numGrp <- length(unique(id_num))

## population (Gbl) work
# knots
numIntKnotsGbl <- 20
# population O-Sull Basis Functions
intKnotsGbl <- quantile(unique(num_weeks)
```

```r
                        , seq(0, 1, length=numIntKnotsGbl+2)
                        )[-c(1, numIntKnotsGbl+2)]
range.num_weeks <- c(min(num_weeks)-0.01, max(num_weeks)+0.01)

Zgbl <- HRW::ZOSull(num_weeks, range.x=range.num_weeks, intKnots=intKnotsGbl)

## subject-level (Grp) work
numIntKnotsGrp <- 10
intKnotsGrp <- quantile(unique(num_weeks)
                        , seq(0, 1, length=numIntKnotsGrp+2)
                        )[-c(1, numIntKnotsGrp+2)]
Zgrp <- HRW::ZOSull(num_weeks, range.x=range.num_weeks, intKnots=intKnotsGrp)
```

```r
# random effects structure
dummyId <- factor(rep(1, numObs))
Zblock <- list(
              dummyId = pdIdent( ~ -1 + Zgbl)
              , id_num = pdSymm(~ num_weeks)
              , id_num = pdIdent(~ -1 + Zgrp)
              )
gd <- groupedData(pig_weight ~ num_weeks|rep(1, length=numObs)
                  , data=data.frame(pig_weight, num_weeks, Zgbl, Zgrp, id_num)
                  )
fit_epoch_1 <- lme(pig_weight ~ num_weeks, data=gd, random=Zblock)
```

```
## Warning in lme.formula(pig_weight ~ num_weeks, data = gd, random = Zblock):
## fewer observations than random effects in all level 3 groups
```

Now going to work with the second period.

```r
# extract meaningful variables into objects
id_num <- pigs_epoch_2$id.num
num_weeks <- pigs_epoch_2$num.weeks
pig_weight <- pigs_epoch_2$weight
```

```r
# set up our design matrices.
# number records
numObs <- length(id_num)
# number of subjects
numGrp <- length(unique(id_num))

## population (Gbl) work
# knots
numIntKnotsGbl <- 20
# population O-Sull Basis Functions
intKnotsGbl <- quantile(unique(num_weeks)
                        , seq(0, 1, length=numIntKnotsGbl+2)
                        )[-c(1, numIntKnotsGbl+2)]
range.num_weeks <- c(min(num_weeks)-0.01, max(num_weeks)+0.01)

Zgbl <- HRW::ZOSull(num_weeks, range.x=range.num_weeks, intKnots=intKnotsGbl)

## subject-level (Grp) work
numIntKnotsGrp <- 10
intKnotsGrp <- quantile(unique(num_weeks)
```

```r
                         , seq(0, 1, length=numIntKnotsGrp+2)
                         )[-c(1, numIntKnotsGrp+2)]
Zgrp <- HRW::ZOSull(num_weeks, range.x=range.num_weeks, intKnots=intKnotsGrp)
```

```r
# random effects structure
dummyId <- factor(rep(1, numObs))
Zblock <- list(
              dummyId = pdIdent( ~ -1 + Zgbl)
              , id_num = pdSymm(~ num_weeks)
              , id_num = pdIdent(~ -1 + Zgrp)
              )
gd <- groupedData(pig_weight ~ num_weeks|rep(1, length=numObs)
                  , data=data.frame(pig_weight, num_weeks, Zgbl, Zgrp, id_num)
                  )
fit_epoch_2 <- lme(pig_weight ~ num_weeks, data=gd, random=Zblock)
```

```
## Warning in lme.formula(pig_weight ~ num_weeks, data = gd, random = Zblock):
## fewer observations than random effects in all level 3 groups
```

Now, let's compare the output of these models.

```r
fit_epoch_1$sigma
```

```
## [1] 0.6898007
```

```r
fit_epoch_2$sigma
```

```
## [1] 0.7371322
```