Chapter 1

Chi Zhang

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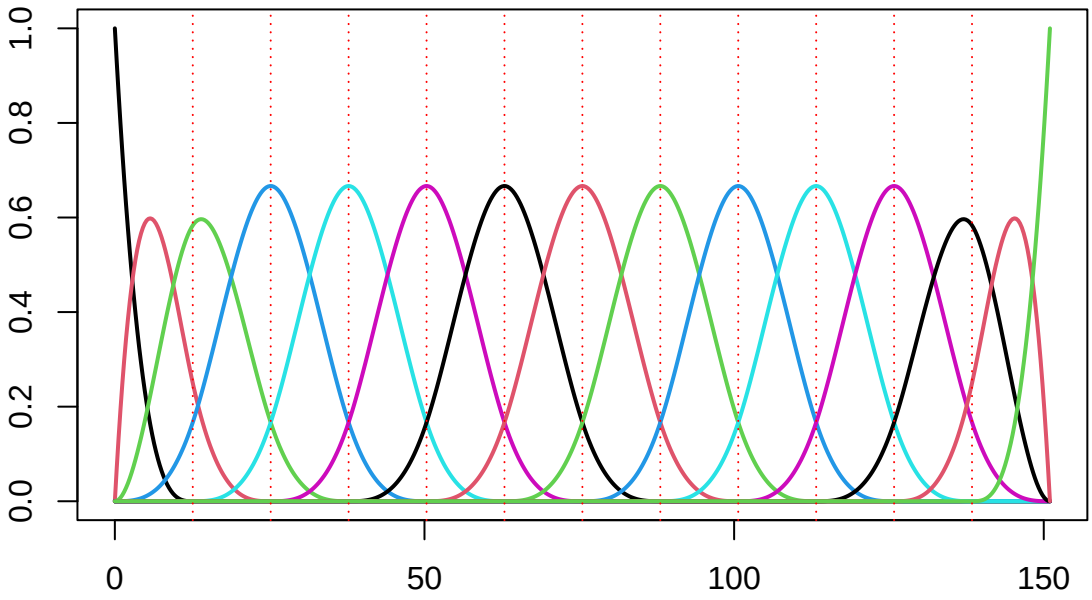
Chapter 1

1.1

The pinch is a dataset included in the fda package. It consists of 151 measurements of pinch force for 20 replications (curves).
(a) Convert the pinch data to functional objects using 15 B-splines of order four (cubic splines) and plot the 20 smoothed curves on one graph.
(b) Calculate the pointwise mean and SD and add them to the plot.
(c) Graph the perspective and contour plots of the sample covariance function $\hat{c}(t, s)$ of the pinch curves.
(d) Graph the first four EFPC's of the pinch data. How many components do you need to explain 90% of variation?

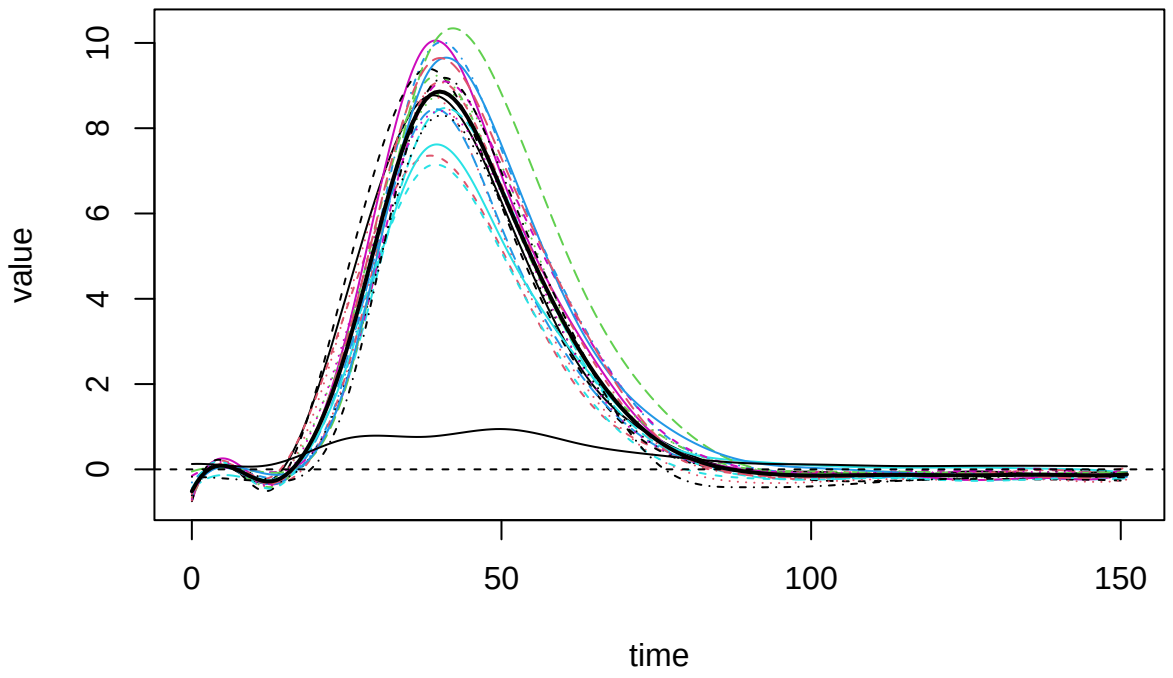
```
df <- pinch
# create and plot 15 B-spline lines with order 4
B15.basis <- create.bspline.basis(rangeval=c(0, 151), nbasis=15, norder=4)
plot(B15.basis, lty=1, lwd=2)
```



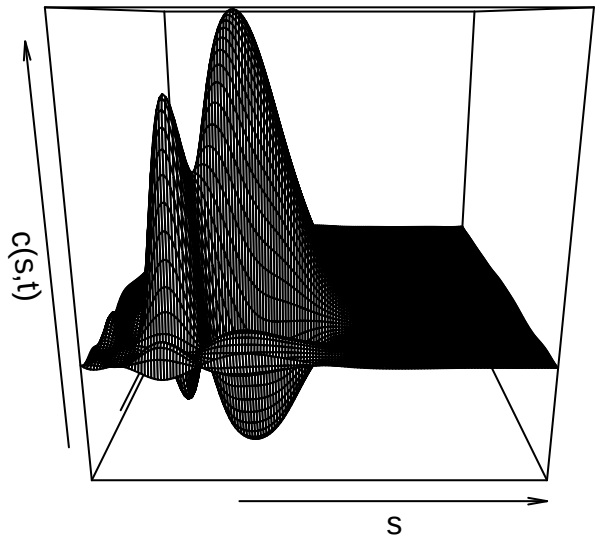

```
# cover pinch into functional objects
# (a)
pinch.fd <- smooth.basis(y=df, fdParobj=B15.basis)
plot(pinch.fd, titles = 'Smoothed pinch functional objects')
```

```
## [1] "done"
```

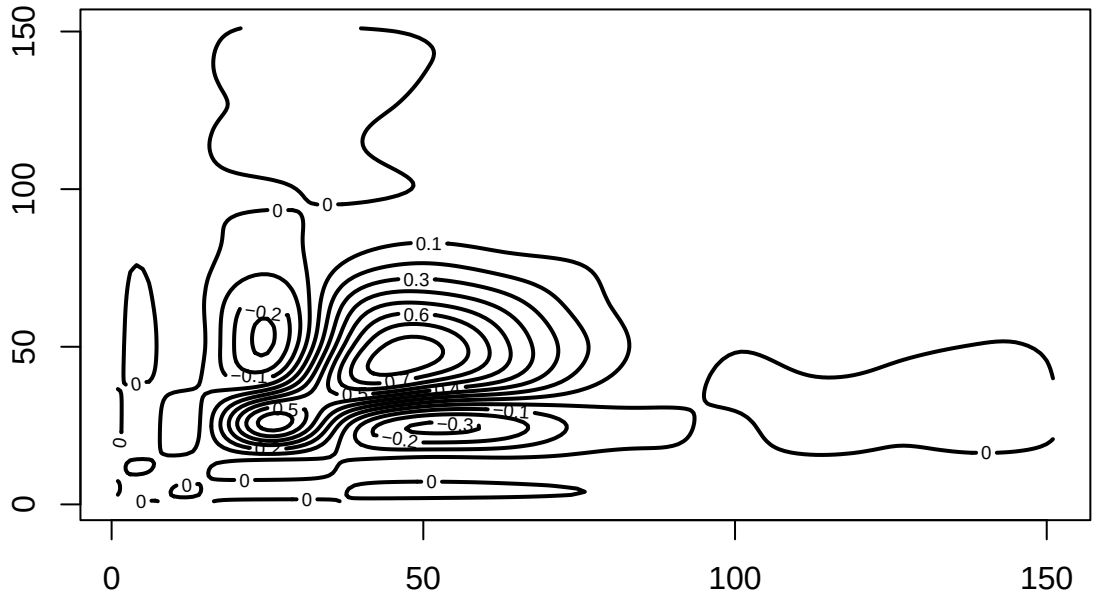
```
# (b)
pinchbar <- mean.fd(pinch.fd$fd)
sdpinch <- std.fd(pinch.fd$fd)
lines(pinchbar, lwd = 2)
lines(sdpinch, lwd = 1)
```




```
# (c)
pinch.cov <- var.fd(pinch.fd$fd)
grid <- seq(1, 151, 1)
pinch.cov.mat <- eval.bifd(grid, grid, pinch.cov)
persp(grid, grid, pinch.cov.mat, xlab="s", ylab="t", zlab="c(s,t)")
```




```
contour(grid, grid, pinch.cov.mat, lwd=2)
```



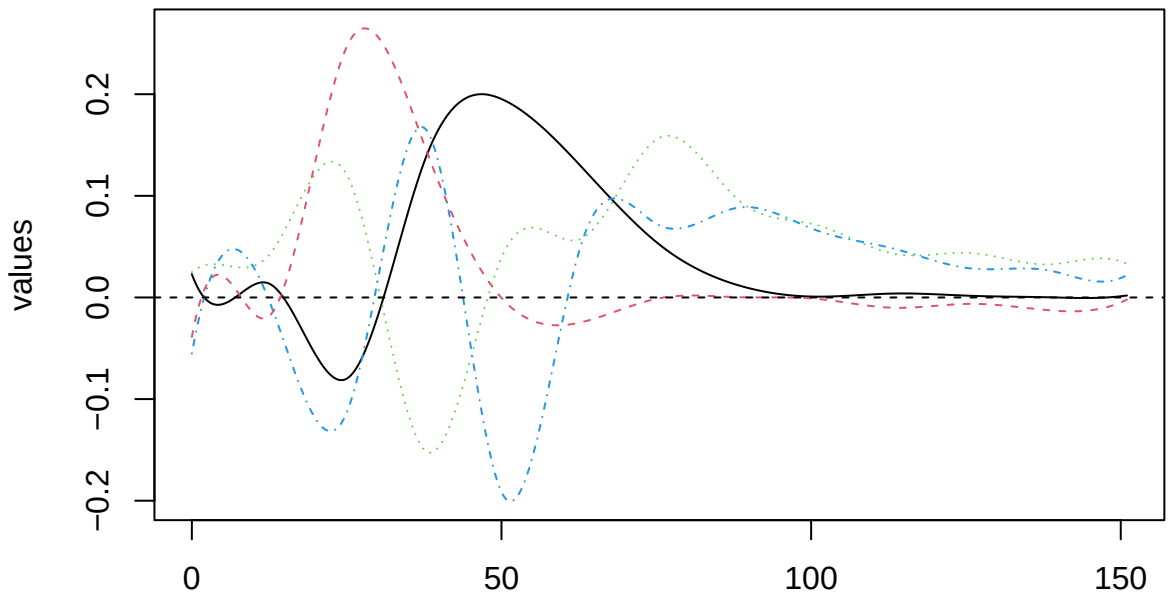

```
# (d)
pinch.pca <- pca.fd(pinch.fd$fd, nharm = 4)
pinch.pca$varprop
```

```
## [1] 0.67188311 0.24767933 0.04669787 0.01957213
```

```
(pinch.pca$varprop)[1:2] %>% sum()
```

```
## [1] 0.9195624
```

```
plot(pinch.pca$harmonics, lwd=3)
```



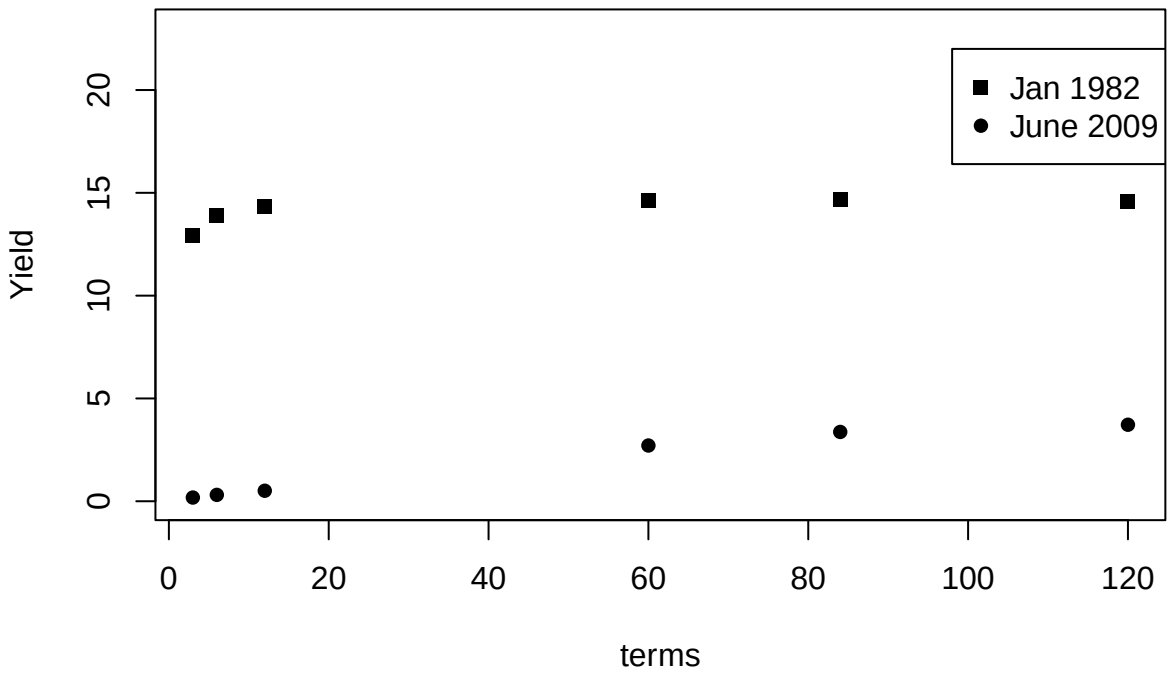

```
## [1] "done"
```

1.2

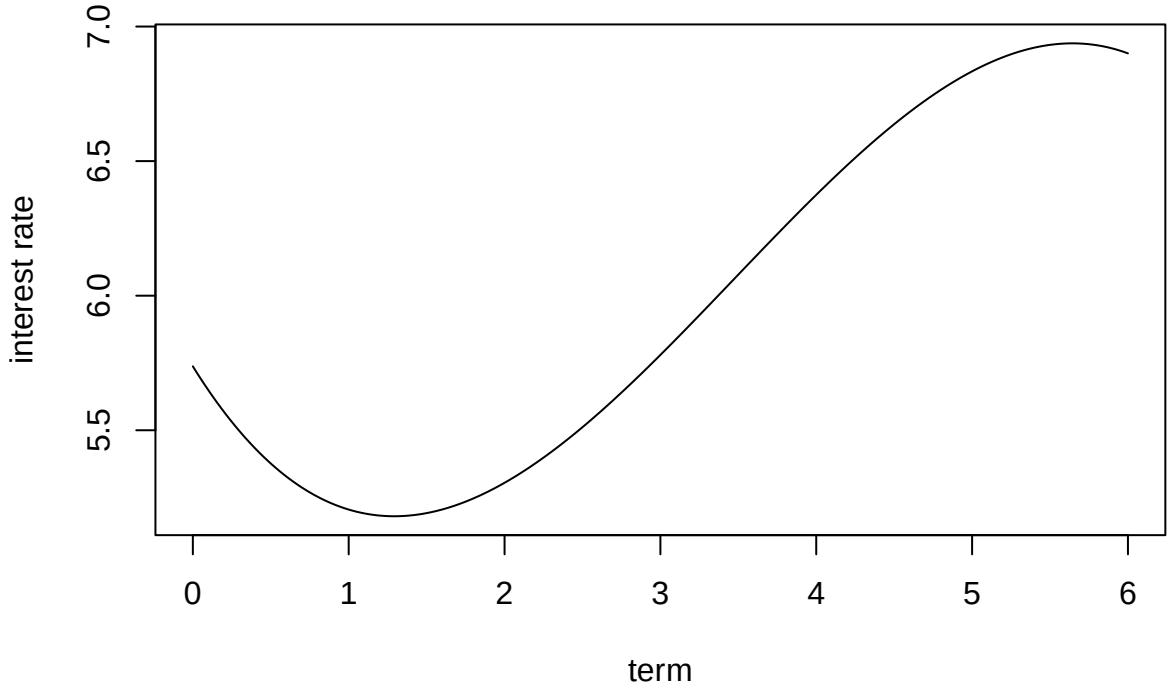
For this problem, download the R package fds and use the data set of the United States Federal Reserve interest rates, FedYieldcurve, which contains the monthly interest rates from January 1982 to June 2009. The x-values are the maturity terms of 3, 6, 12, 60, 84 and 120 months which can be identified with the t_j in this chapter. The y-values are the interest rates of the United States Treasury obligations due in x months which can be identified with the $x_n(t_j)$, where n is a month in the range January 1982 to June 2009.
(a) On one graph, plot the interest rates $x(t_j)$ for January 1982 and for June 2009 against the maturity terms t_j . How do the interest rates in these two months compare? Use the following code:

```
library(fds)
library(fda)
yield = FedYieldcurve; terms = yield$x
plot(terms, yield$y[,1], pch=15, ylab="Yield", ylim=c(0,16))
points(terms, yield$y[,330], pch=16)
```

```
# (a)
yield = FedYieldcurve
terms = yield$x
plot(terms, yield$y[, 1], pch=15, ylab="Yield", ylim=c(0, 23))
points(terms, yield$y[, 330], pch=16)
legend(x = 98, y = 22, legend = c('Jan 1982', 'June 2009'), pch = 15:16)
```




```
# (b)
B4.basis <- create.bspline.basis(rangeval=c(0, dim(yield$y)[1]), nbasis=4, norder=4)
yield.fd <- smooth.basis(y=yield$y, fdParobj = B4.basis)
# plot(yield.fd$fd) <<---- not informative
yield.mean <- mean.fd(yield.fd$fd)
plot(yield.mean, xaxt = "n", xlab = 'term',
     col = 'blue', ylab = 'interest rate') # <<-- xaxt not work properly
```

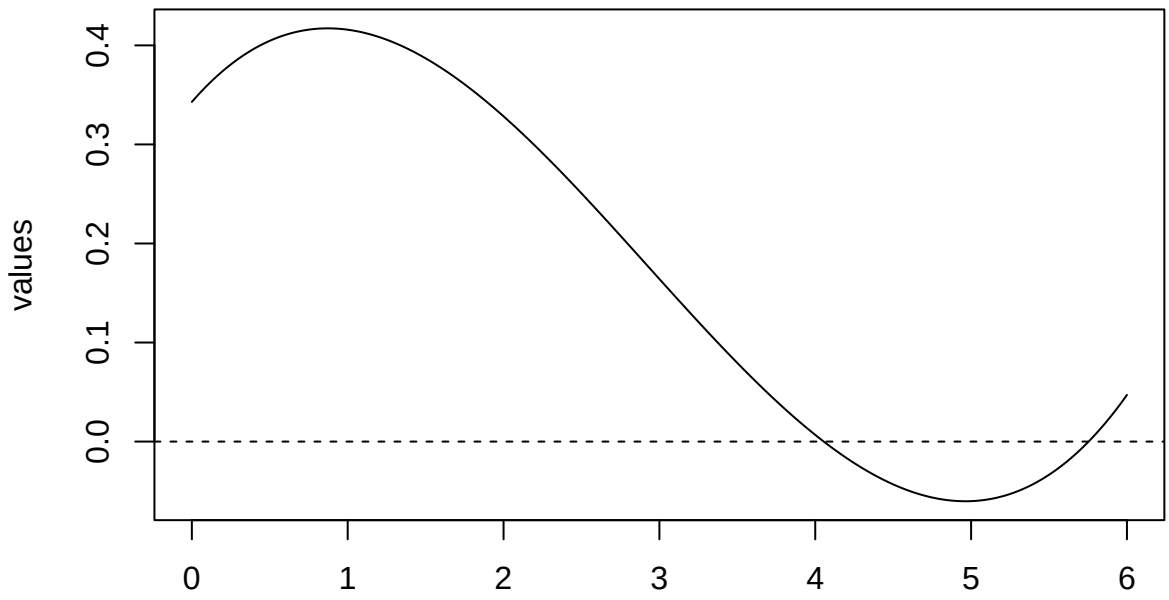



```
## [1] "done"
```

```
# xtick = seq(0, 6, 1)
# axis(side=1, at=xtick, labels = c(0, 3, 6 , 12, 60, 84, 120))
# (c)
yield.pca <- pca.fd(yield.fd$fd, nharm = 1)
yield.pca$varprop
```

```
## [1] 0.9820195
```

```
plot(yield.pca$harmonics)
```




```
## [1] "done"
```