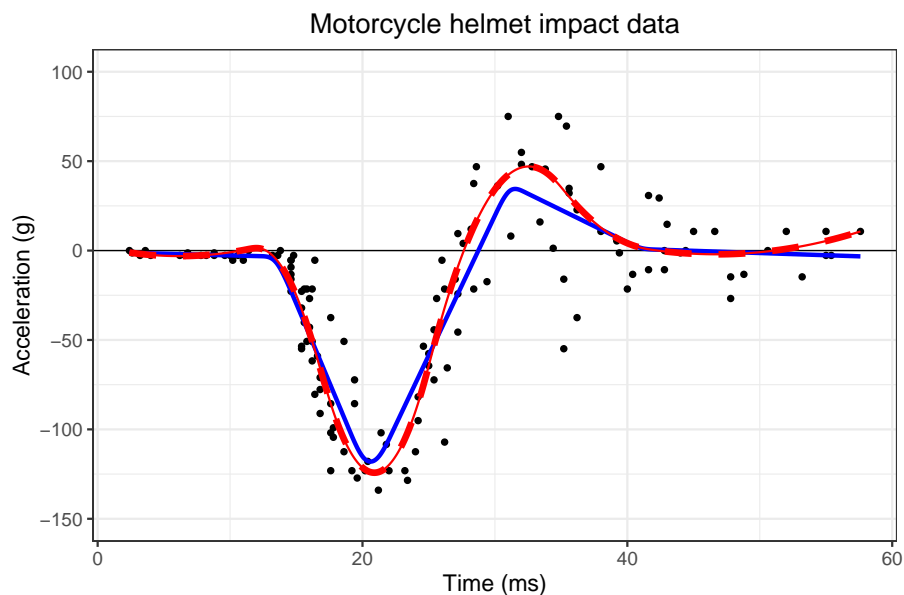


Median P-spline smoothing with large basis (Motorcycle data)



Median smoothing of the motorcycle data using cubic P-splines, with 50 segments on the domain from 0 to 60 ms, second order differences and $\lambda = 10$ (blue full line). The piecewise-linear shape is a consequence of the sum of absolute values in the penalty. With third order differences, the curve becomes piecewise quadratic (red broken line). R code in `f-mot-median-d3.R`

```
# Median smoothing with larger P-spline basis (Motorcycle data)
# A graph in the book 'Practical Smoothing. The Joys of P-splines'
# Paul Eilers and Brian Marx, 2019
```

```
library(ggplot2)
library(gridExtra)
library(colorspace)
library(MASS)
library(quantreg)
library(JOPS)

# Get the data
data(mcycle)
x = mcycle$times
y = mcycle$accel

# Add outliers x = c(x, 5, 50) y = c(y, -150, 100)

# Compute the B-spline basis
deg = 3
xlo = min(x)
xhi = max(x)
ndx = 50
B = bbasis(x, xlo, xhi, nseg = ndx, bdeg = deg)

# Basis for fit on grid
ng = 1000
xg = seq(min(x), max(x), length = ng)
Bg = bbasis(xg, xlo, xhi, nseg = ndx, bdeg = deg)
n = ncol(B)

# Fit with second order penalty
```

```

d = 2
D = diff(diag(n), diff = d)
lambda = 10
Bplus = rbind(B, lambda * D)
yplus = c(y, rep(0, n - d))

# Estimate the coefficients and compute fit on the grid
qfit = rq(yplus ~ Bplus - 1)
a = coefficients(qfit)
z1 = Bg %*% a

# Fit with third order penalty
d = 3
D = diff(diag(n), diff = d)
lambda = 10
Bplus = rbind(B, lambda * D)
yplus = c(y, rep(0, n - d))

# Estimate the coefficients and compute fit on the grid
qfit = rq(yplus ~ Bplus - 1)
a = coefficients(qfit)
z2 = Bg %*% a

# Create data frames for ggplot
Zf1 = data.frame(x = xg, y = z1, id = as.factor(1))
Zf2 = data.frame(x = xg, y = z2, id = as.factor(1))

# Build the graph
Data = data.frame(x, y)
plt1 = ggplot(Data, aes(x = x, y = y)) +
  geom_point(size = 1) +
  geom_hline(yintercept = 0, size = 0.3) +
  geom_line(data = Zf1, size = 1, colour = I("blue"), lty = 1) +
  geom_line(data = Zf2, size = 0.5, colour = I("red"), lty = 1) +
  geom_line(data = Zf2, size = 1.5, colour = I("red"), lty = 2) +
  xlab("Time (ms)") + ylab("Acceleration (g)") +
  ggtitle("Motorcycle helmet impact data") +
  ylim(c(-150, 100)) +
  JOPS_theme()

print(plt1)

```
