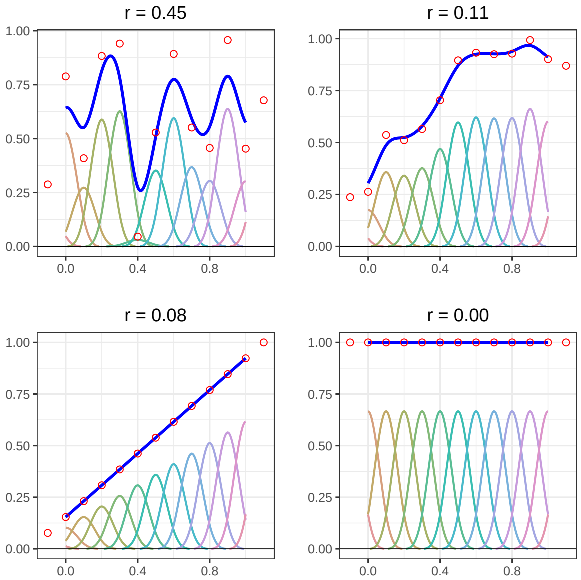
B-spline fits with same basis having varying roughness



An illustration of how roughness of the mean μ can vary dramatically while using exactly the same basis B. The roughness of the curve only depends on the roughness of the coefficients α, measured by r. The red circles show the values of the individual coefficients associated with their corresponding B-splines. R code in f-brough2.R

```
# B-spline fits with same basis having varying roughness
# A graph in the book 'Practical Smoothing. The Joys of P-splines'
# Paul Eilers and Brian Marx, 2019

library(ggplot2)
library(gridExtra)
library(JOPS)
library(colorspace)

# Make basis
nu = 200
u = seq(0, 1, length = nu)
nseg = 10
B = bbase(u, nseg = nseg)
n = ncol(B)
set.seed(123)

# Make coefficients
a1 = runif(n)
a2 = 0.8 * sin(2 * (1:n)/n) + runif(n) * 0.2
a3 = (1:n)/n
a4 = rep(1, n)
A = cbind(a1, a2, a3, a4)
Z = B %*% A

# Generate the plots
plts = list()
for (j in 1:4) {

  # Compute roughness
  aj = c(A[, j])
  da = diff(aj)
  r = sqrt(sum(da ^ 2)/(n - 1))
  sr = sprintf("r = %3.2f", r)

  # Scaled basis
  Bsc = B %*% diag(aj)

  # Create data frames for ggplot
  id = as.factor(rep(1:n, each = nu))
  Zf = data.frame(x = u, y = Z[, j], id  = as.factor(1))
  Bf = data.frame(x = rep(u, n), y = as.vector(Bsc), id = id)

  # Remove zero entries
  Bf$y[Bf$y < 0.0001] = NA
  Bf = na.omit(Bf)

  knots = ((1:n) - 2) / nseg
  Fa = data.frame(x = knots, y = aj, id = 1)

  # Build the graphs
  plt1 = ggplot(Bf, aes(x = x, y = y, group = id, colour = id)) +
    geom_line( size = 0.7) +
    ggtitle(sr) +
    geom_hline(yintercept = 0, size = 0.3) +
    geom_line(data = Zf, size = 1, col = "blue") +
    geom_point(data = Fa, color = "red", size = 2, shape = 1) +
    xlab("") + ylab("") +
    JOPS_theme() +
    theme(legend.position = "none") +
    scale_color_manual(values=rainbow_hcl(n, start = 10, end = 350))

  # Add to list of plots
  plts[[j]] = plt1
}

# Plot and save
grid.arrange(grobs = plts, nrow = 2, ncol = 2)
```