1 Introduction

We provide a code example for a simple asset-selection model; please see Gilli et al. [2011, ch. 12 and 13] for more details. The code example here differs slightly from the book’s presentation. To see the latter, check the script `exampleLS.R` (after attaching the package):

```r
> showExample("exampleLS", chapter = "Portfolio")
```

We start by attaching the package and fixing a seed.

```r
> require("NMOF")
> set.seed(112233)
```

2 The model

We wish to select between $K_{\text{min}}$ and $K_{\text{max}}$ out of $n_A$ assets such that an equally-weighted portfolio of these assets has the lowest-possible variance. The formal model is:

$$
\min_w w' \Sigma w
$$

subject to the constraints

$$
w_j = \frac{1}{K}, \quad \text{for } j \in J, \\
K_{\text{min}} \leq K \leq K_{\text{max}}.
$$

The weights are stored in the vector $w$; the symbol $J$ stands for the set of assets in the portfolio; and $K = \# \{J\}$ is the cardinality of this set, ie, the number of assets in the portfolio.

3 Setting up the algorithm

We simulate 500 assets: each gets a random volatility between 20% and 40%, and all pairwise correlations are set to 0.6.

```r
> na <- 500L ## number of assets
> C <- array(0.6, dim = c(na, na)) ## correlation matrix
> diag(C) <- 1
> minVol <- 0.20; maxVol <- 0.40 ## covariance matrix
> Vols <- (maxVol - minVol) * runif(na) + minVol
> Sigma <- outer(Vols, Vols) * C
```

The objective function.

```r
> OF <- function(x, Data) {
    w <- x/sum(x)
    res <- crossprod(w[x], Data$Sigma[x, x])
    tcrossprod(w[x], res)
}
```

…or even simpler:
The neighbourhood function.

```r
neighbour <- function(xc, Data) {
  xn <- xc
  p <- sample.int(Data$na, Data$nc, replace = FALSE)
  xn[p] <- !xn[p]
  ## reject infeasible solution
  if (sum(xn) > Data$Kmax || sum(xn) < Data$Kmin)
    xc
  else
    xn
}
```

We collect all necessary information in the list `Data`: the variance–covariance matrix `Sigma`, the cardinality limits `Kmin` and `Kmax`, the total number of assets `na` (i.e., the cardinality of the asset universe), and the parameter `nc`. This parameter controls the neighbourhood: it gives the number of assets that are to be changed when a new solution is computed.

```r
Data <- list(Sigma = Sigma,
              Kmin = 30L,
              Kmax = 60L,
              na = na,
              nc = 1L)
```

### 4 Solving the model

As an initial solution, we use a random portfolio.

```r
card0 <- sample(Data$Kmin:Data$Kmax, 1L, replace = FALSE)
assets <- sample.int(na, card0, replace = FALSE)
x0 <- logical(na)
x0[assets] <- TRUE
```

With this implementation, we assume that `Data$Kmax > Data$Kmin`. (If `Data$Kmax equals Data$Kmin`, then `sample` returns a draw from `1:Data$Kmin`.)

We collect all settings for the algorithm in a list `algo`.

```r
algo <- list(x0 = x0,
              neighbour = neighbour,
              nS = 5000L,
              printDetail = FALSE,
              printBar = FALSE)
```

It remains to run the algorithm.

```r
system.time(sol1 <- LSopt(OF, algo, Data))

          user  system elapsed
        0.112   0.020   0.132
```

```r
sqrt(sol1$OFvalue)
          [,1]
[1,] 0.163
```
(Recall that the simulated data had volatilities between 20 and 40%.)
We can also run the search repeatedly with the same starting value.

```r
> nRuns <- 3L
> allRes <- restartOpt(LSopt, n = nRuns, OF, algo = algo, Data = Data)
> allResOF <- numeric(nRuns)
> for (i in seq_len(nRuns))
>   allResOF[i] <- sqrt(allRes[[i]]$OFvalue)
> par(bty = "n", las = 1, tck = 0.01, mar = c(4,4,1,1))
> plot(ecdf(allResOF), xlab = "x: Portfolio volatility", pch = 21,
>     main = "")
```

(We run LSopt only 3 times to keep the build time for the vignette acceptable. To get more meaningful results you should increase nRuns.)

**References**