The law of large numbers (LLN)

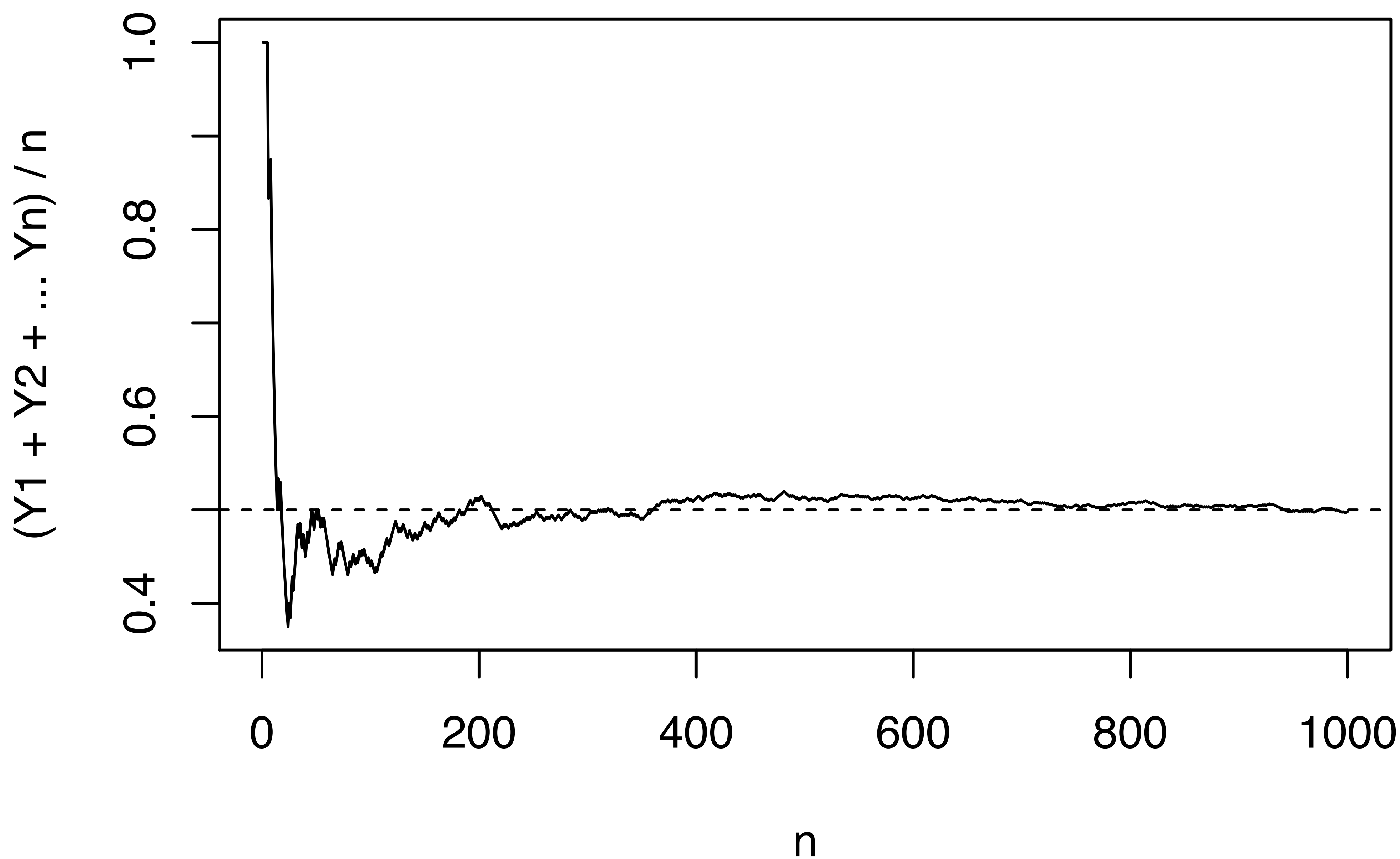
If the random sample are i.i.d., and the population variance is finite ($\sigma_Y^2 < \infty$), then the sample mean $\overline{Y}$ converges to the population mean μ_Y in probability as the sample size increases ($n \to \infty$).

- Converges in probability:
  The probability that $\mu_Y - c < \overline{Y} < \mu_Y + c$ becomes arbitrarily close to 1 as n increases for any constant $c > 0$.

- There are other versions of LLN.

Demonstrating the LLN

- The sample mean of n Bernoulli random variables (flipping a fair coin n times).



```r
n <- 1000
obs <- rbinom(n,1,1/2)

sm_obs <- rep(0,n)

for (i in 1:n) {
  sm_obs[i] <- sum(obs[1:i]) / i
}

plot(1:n, sm_obs, type = "l", xlab = "n",
ylab = "(Y1 + Y2 + ... Yn) / n")
abline(0.5, 0, lty = 2)
```

Practice: matrix multiplication

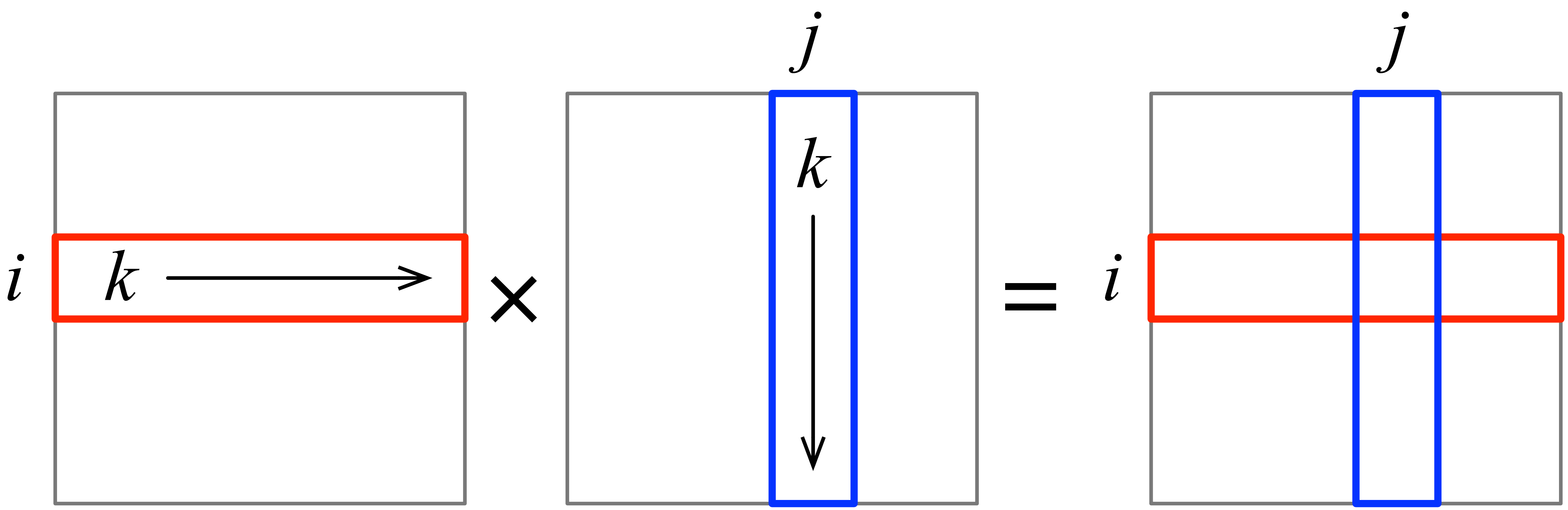
- Write a function that calculates the product of two square matrices with the same size using `for` statement (and without using `%*%` command). Create two matrices of arbitrary size and test your function.

- For example:

```
matmul <- function (a, b) {
    ……
    ……
    return(…)
}
```

Practice: matrix multiplication

$$A \times B = C \quad \Leftrightarrow \quad C_{ij} = \sum_k A_{ik} \times B_{kj}$$



Practice: matrix multiplication

```
matmul <- function (x, y) {
  n <- nrow(x)
  z <- matrix(rep(0, n^2), n, n)
  for (i in 1:n) {
    for (j in 1:n) {
      for (k in 1:n) {
        z[i,j] <- z[i,j] + x[i,k] * y[k,j]
      }
    }
  }
  return(z)
}
```