

Use R to Compute Numerical Integrals

In short, you may use R to find out a numerical answer to an n -fold integral, $n \leq 20$.

- I. To integrate a one-dimensional integral over a finite or infinite interval, use R function `integrate`. For example, find out

$$\int_0^{\infty} \frac{1}{(x+1)\sqrt{x}} dx$$

```
>## define the integrated function
>integrand <- function(x) {1/((x+1)*sqrt(x))}
>## integrate the function from 0 to infinity
>integrate(integrand, lower = 0, upper = Inf)
3.141593 with absolute error < 2.7e-05
```

The numerical answer is 3.141593 up to a small error 2.7×10^{-5} .

Another example is to find out

$$\int_{-1.96}^{1.96} \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} dx$$

```
>f <- function(x) {1/sqrt(2*pi)*exp(-x^2/2)}
>integrate(f, lower = -1.96, upper = 1.96)
0.9500042 with absolute error < 1.0e-11
```

For more information about the function `integrate`, type `help(integrate)` in R.

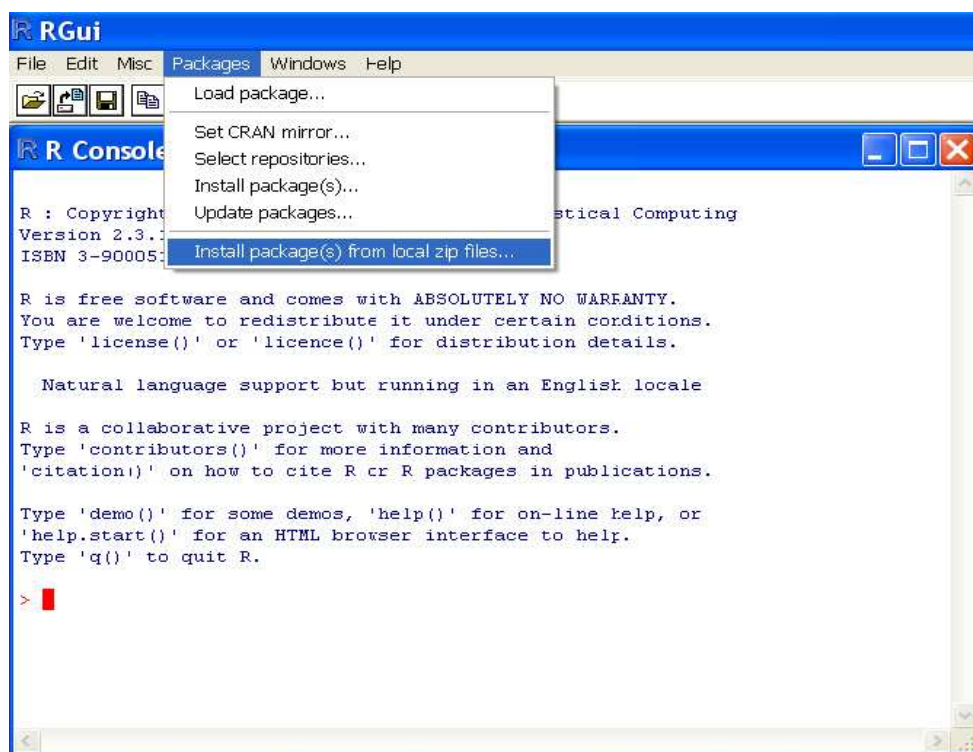
- II. To integrate a scalar function over a multidimensional rectangle, use R function `adapt`. To use `adapt`, you need to install the R package `adapt` first:

- (1) Download the package file “`adapt_1.0-3.zip`” via

<http://cran.r-project.org/src/contrib/Descriptions/adapt.html>

- (2) Install the package `adapt` in R.

- (i) Click R menu “packages”.
- (ii) Click the subitem “Install package(s) from local zip files...” .
- (iii) Open the downloaded package file “`adapt_1.0-3.zip`” .



For more R packages, please check
<http://cran.r-project.org/src/contrib/PACKAGES.html>

Now you can use the R function `adapt` to compute n -fold integrals, $2 \leq n \leq 20$. For example, find out the integral

$$\int_0^{\frac{1}{2}} \int_0^{\frac{1}{2}} \int_0^{\frac{1}{2}} \frac{2}{3}(x_1 + x_2 + x_3) dx_1 dx_2 dx_3$$

```
> library(adapt)           # load the package "adapt"
> f <- function(x) { 2/3 * (x[1] + x[2] + x[3]) } # "x" is vector
> ## In adapt, "3"=dimension, "lo"=lower bounds, "up"=upper bounds
> adapt(3, lo = c(0, 0, 0), up = c(0.5, 0.5, 0.5), functn = f)
      value      relerr    minpts    lenwrk    ifail
0.06249999 2.234574e-07      225        54         0
```

So the numerical answer for the 3-dimensional integral is 0.06249999 up to a small error rate 2.234574×10^{-7} .

For more information about the function `adapt`, type `help(adapt)` after loading the package *adapt* in R.