Interoperability between R and OpenModelica

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Agenda

- Introduction to the R Programming Language
- Objective and Approach
- System Specifications
- Example: General-purpose Optimization
- Operations performed
- Results
- Code on GitHub
- Limitations of current approach
- Future Work

Introduction to the R Programming Language

- **R is a programming language for statistical computing and graphics.**
- **R provides a wide variety of statistical and graphical techniques and is highly extensible.**
- **R currently provides access to 18830 external packages.**
- **Practical applications in business, drug advancement, finance, health care, marketing, medicine, etc.**

Figure 1: **R logo**

Objective and Approach

- **Call C from OpenModelica and pass parameter values to it.**
- **Call R from C and pass parameter values to R.**
- **Print results obtained from R and read them as a single string in C.**
- **Segregate the string into an array and convert every element to a floating-point number.**
- **Pass those floating-point numbers to OpenModelica.**

Objective and Approach Contd...

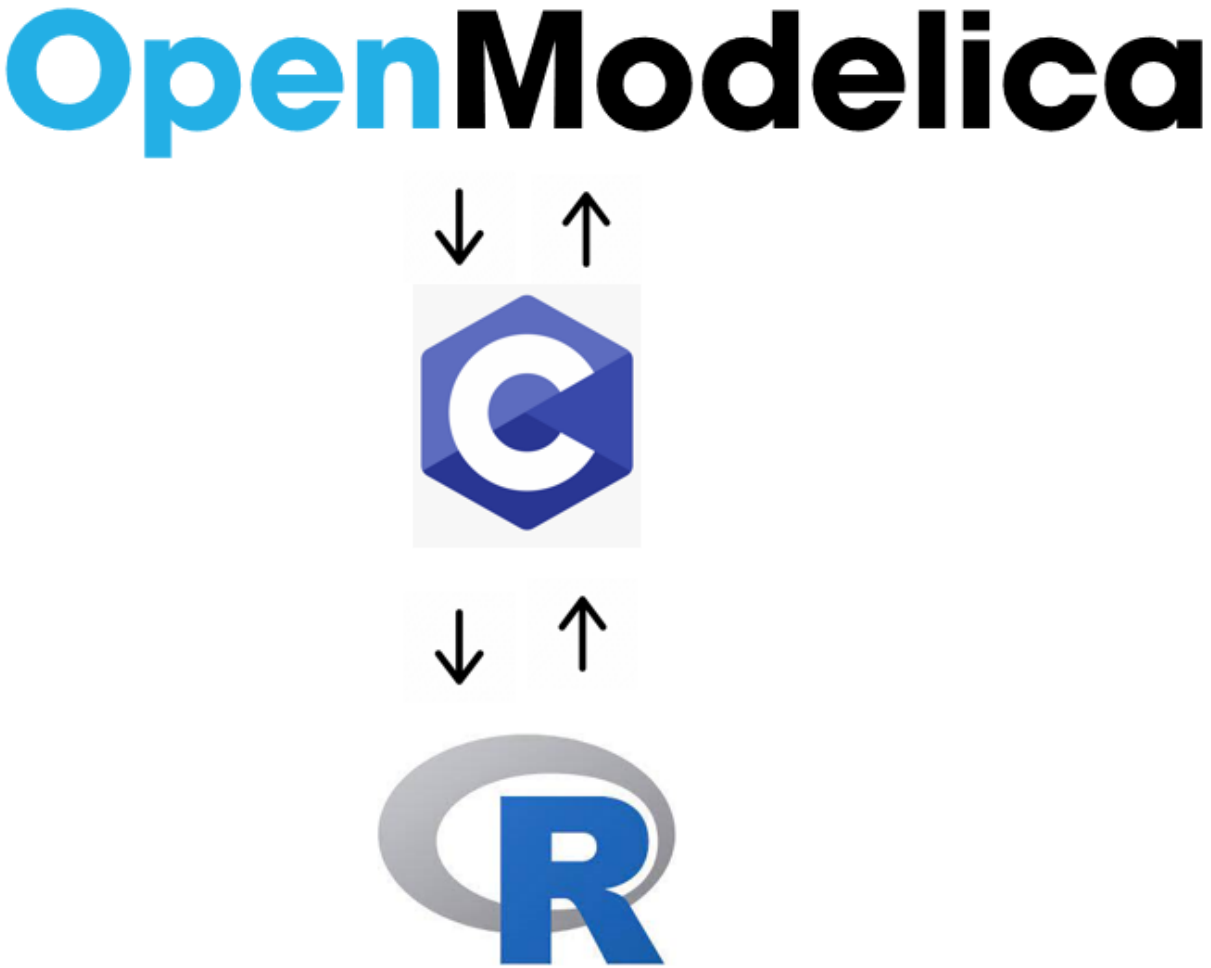


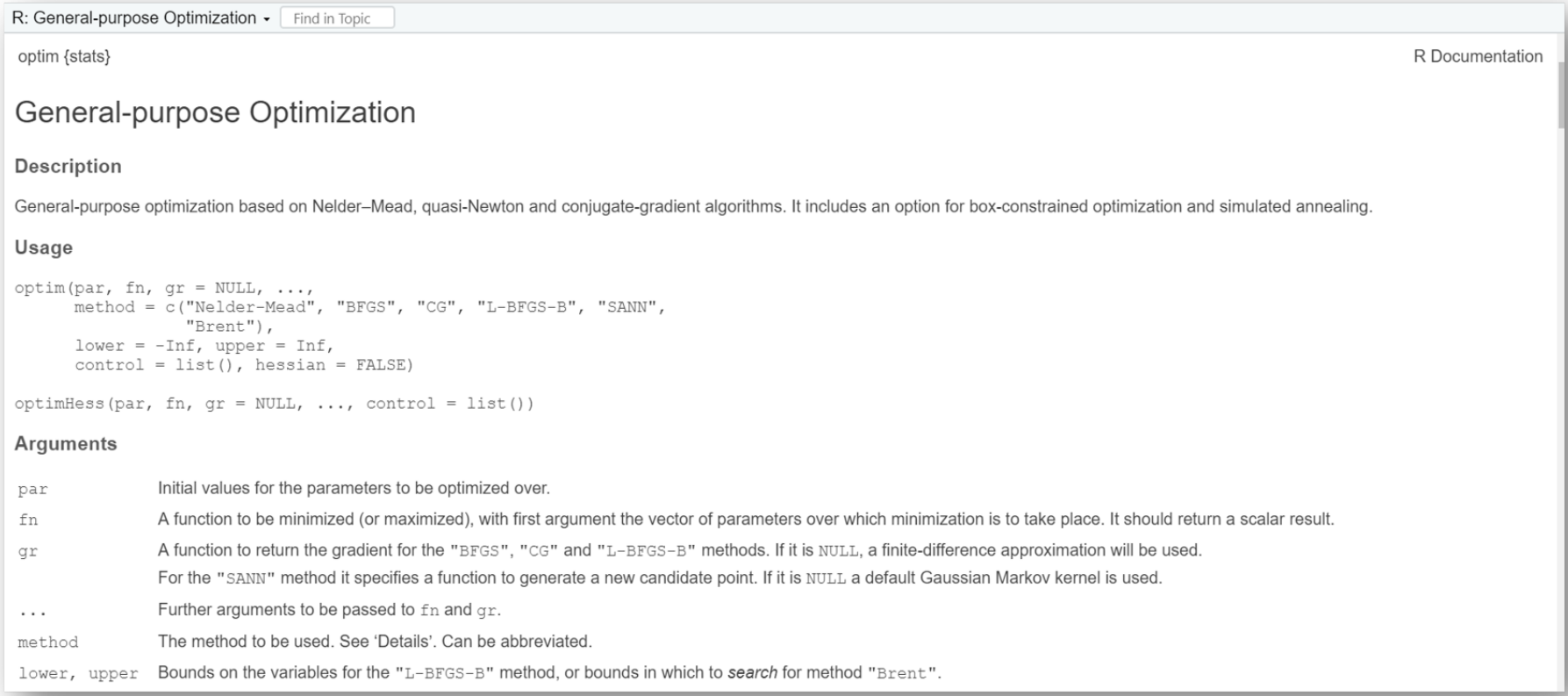
Figure 2: **Procedure implemented for interoperability**

System Specifications

Interoperability was implemented on the following -

- **Windows 10 (64-bit operating system)**
- **R 3.6.3 (64-bit)**
- **Open-Modelica v1.16.0-dev-371-geb234c072 (64-bit)**

Example: General-purpose Optimization



R: General-purpose Optimization ▾ Find in Topic

optim {stats} R Documentation

General-purpose Optimization

Description

General-purpose optimization based on Nelder–Mead, quasi-Newton and conjugate-gradient algorithms. It includes an option for box-constrained optimization and simulated annealing.

Usage

```
optim(par, fn, gr = NULL, ...,
      method = c("Nelder-Mead", "BFGS", "CG", "L-BFGS-B", "SANN",
                 "Brent"),
      lower = -Inf, upper = Inf,
      control = list(), hessian = FALSE)

optimHess(par, fn, gr = NULL, ..., control = list())
```

Arguments

`par`	Initial values for the parameters to be optimized over.
`fn`	A function to be minimized (or maximized), with first argument the vector of parameters over which minimization is to take place. It should return a scalar result.
`gr`	A function to return the gradient for the `"BFGS"`, `"CG"` and `"L-BFGS-B"` methods. If it is `NULL`, a finite-difference approximation will be used. For the `"SANN"` method it specifies a function to generate a new candidate point. If it is `NULL` a default Gaussian Markov kernel is used.
`...`	Further arguments to be passed to `fn` and `gr`.
`method`	The method to be used. See 'Details'. Can be abbreviated.
`lower, upper`	Bounds on the variables for the `"L-BFGS-B"` method, or bounds in which to *search* for method `"Brent"`.

Figure 3: **General-purpose optimization in R using optim() function**

Operations performed

- **Running external C file**

```
external "C" annotation(Library={"Interoperate", "
    Function.dll","Gradient.dll"}, LibraryDirectory="
    modelica://R_OM");
```

Code 1: Running external C file

- **Calling R from C**

```
char cmd[1000]="";
strcat(cmd, "Rscript OMR.R ");
char str1[100];
sprintf(str1, "%g", initial_par); // Store the integer
     value
"initial_par" as a string
strcat(cmd, str1);
strcat(cmd, " ");
```

Code 2: Calling R from C

Operations performed Contd...

- **Printing results from R on console**

```
cat(res_par,res_value,res_fn_counts,res_gr_counts,res_
    convergence)
```

Code 3: Printing results from R on console

- **Obtaining results in C**

```
// Create a buffer to read output from console
int buffersize = 100000;
char buf[buffersize];
FILE *fp;
if ((fp = popen(cmd, "r")) == NULL) {
printf("Error while opening pipe!\n");
}
while (fgets(buf, buffersize, fp) != NULL) {
```

Operations performed Contd...

```
// printf("\nOutput value : %s", buf);
char str[strlen(buf)];
strcpy(str, buf);
// printf("\n Copied Output value : %s", str);
// Split the string and store it in a character array
char *p = strtok(str, " ");
char *array[5];
int i = 0;
while (p != NULL)
{
array[i++] = p;
p = strtok (NULL, " ");
}
```

Operations performed Contd...

```
for (int i = 0; i < 5; ++i)
{
// printf("%s\n", array[i]);
// Copy the output
output[i] = atof(array[i]);
// printf("%f\n", output[i]);
}
return 0;
}
pclose(fp);
```

Code 4: Obtaining results in C

Results

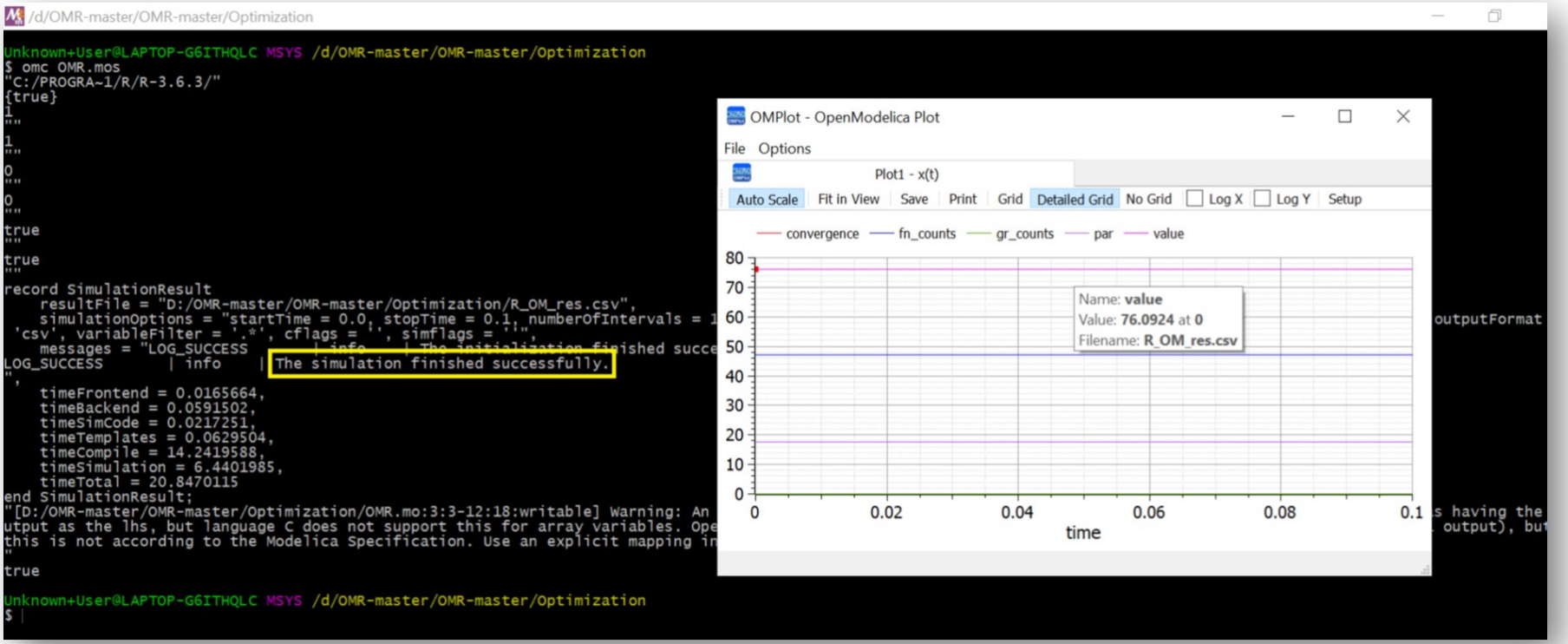


Figure 4: **Results obtained after simulation**

Code on GitHub

- **Link:** `https://github.com/chrl3hr5/OMR`

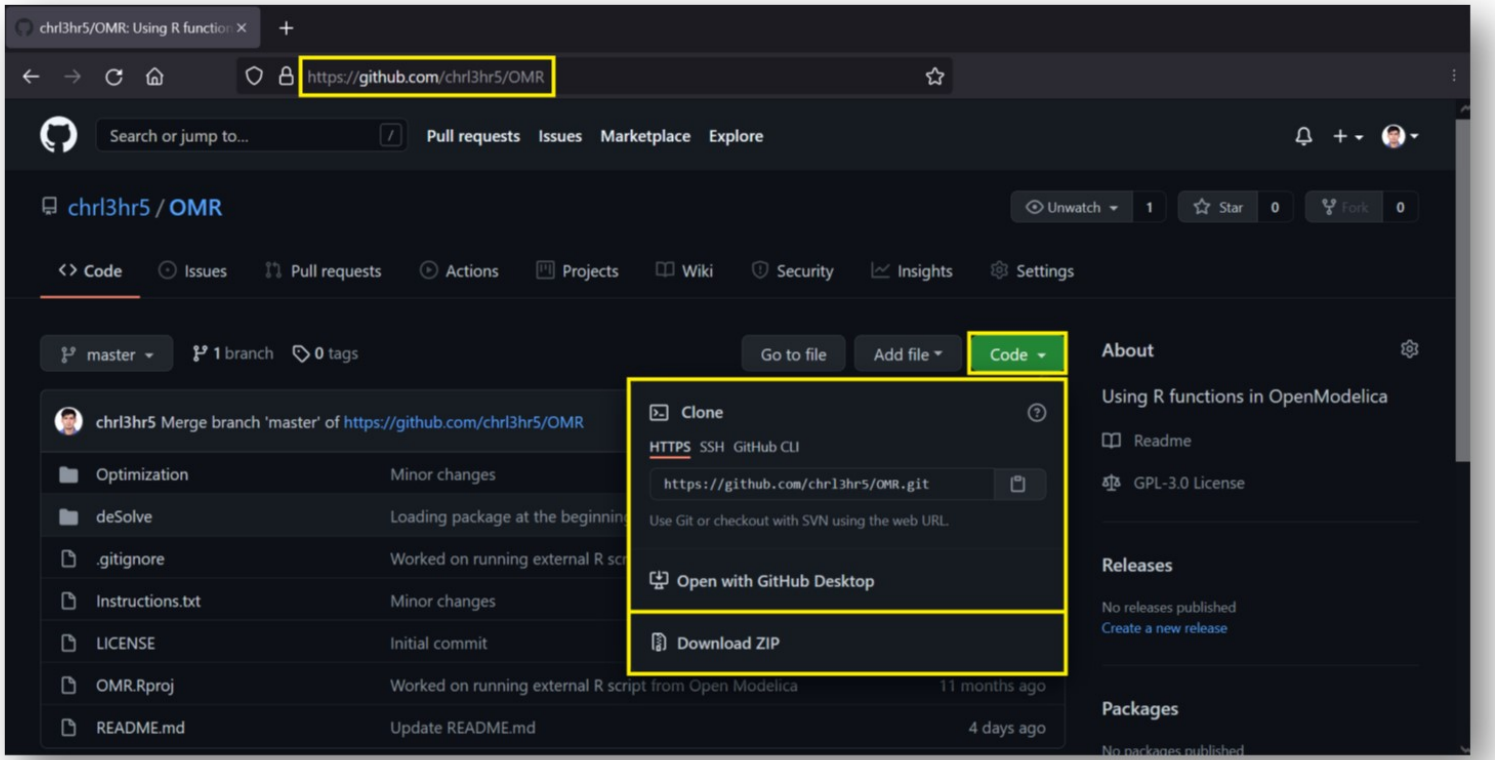


Figure 5: **Download complete code from GitHub**

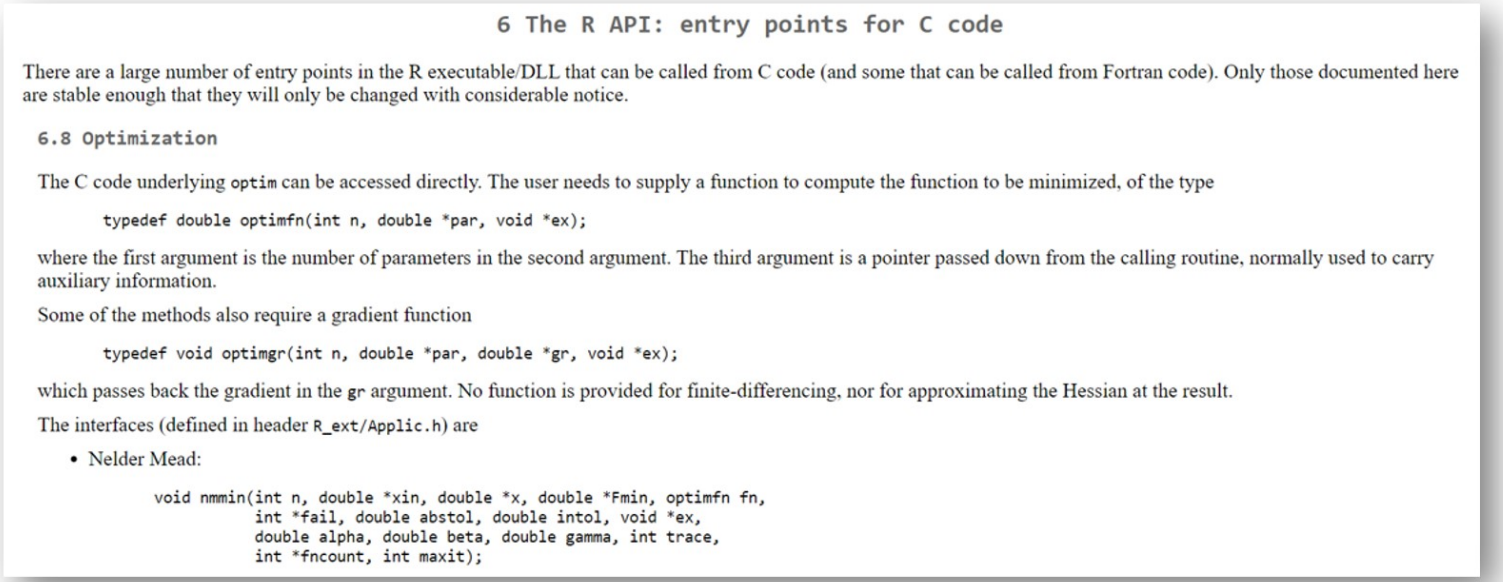
Limitations of current approach

Following are the limitations of the current approach -

- **User must have some knowledge of both R and C.**
- **It is required to know the number of expected outputs from R beforehand.**
- **Depending upon the input parameter values, it could be required to make changes in both the C and R scripts for the program to work.**

Future Work

- **Future work involves the utilization of R API as an alternative approach for R & OpenModelica interoperability and implementation of the same over the Linux operating system.**



6 The R API: entry points for C code

There are a large number of entry points in the R executable/DLL that can be called from C code (and some that can be called from Fortran code). Only those documented here are stable enough that they will only be changed with considerable notice.

6.8 Optimization

The C code underlying `optim` can be accessed directly. The user needs to supply a function to compute the function to be minimized, of the type

```
typedef double optimfn(int n, double *par, void *ex);
```

where the first argument is the number of parameters in the second argument. The third argument is a pointer passed down from the calling routine, normally used to carry auxiliary information.

Some of the methods also require a gradient function

```
typedef void optimgr(int n, double *par, double *gr, void *ex);
```

which passes back the gradient in the `gr` argument. No function is provided for finite-differencing, nor for approximating the Hessian at the result.

The interfaces (defined in header `R_ext/Applic.h`) are

- Nelder Mead:

```
void nmmin(int n, double *xin, double *x, double *Fmin, optimfn fn,
           int *fail, double abstol, double intol, void *ex,
           double alpha, double beta, double gamma, int trace,
           int *fncount, int maxit);
```

Figure 6: **R API**

- **Source:** `https://cran.r-project.org/doc/manuals/r-release/R-exts.html#The-R-API`