

rtkore: R and STK++ Integration using Rcpp

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Abstract

This vignette gives some hints about the usage of the `rtkore` (successor of the `rtkpp`) package. It explains shortly how to wrap R vectors and matrices into STK++ structures. It gives also an example of Makevars for linking an R package with `rtkore`. More informations can be found in the other vignettes coming with the package about the functionalities furnished by the STK++ library.

1 Introduction

STK++ is a versatile, fast, reliable and elegant collection of C++ classes for statistics, clustering, linear algebra (using native methods or Lapack[1]), arrays (with an Eigen-like API [2]), regression, dimension reduction, etc. Some functionalities provided by the library are available in the R environment as R functions or distributed as R packages (`MixAll` [6], `blockcluster` [7] and `HDPenReg` [5] among others).

The `rtkore` package provides a subset of the STK++ library and is only composed of templated classes and inlined functions. This package furnishes implementations of `Rcpp::as` and `Rcpp::wrap` for the C++ classes defined in STK++. In this sense it is similar to the `RcppEigen` [3, 2] and `RcppArmadillo` [4] packages.

The current version of the `stk++` library is given below

```
> .Call("stk_version", FALSE, PACKAGE="rtkore")
major minor patch
  0      9    20
```

2 Wrapping R data with STK++ arrays

`rtkore` proposes two objects in order to facilitate data transfer

```
typename RVector<Type>;
typename RMatrix<Type>;
```

`Rcpp` facilitates conversion of objects from R to C++ through the templated functions `Rcpp::as`. The function `Rcpp::as` is re-implemented in STK++ but it is not strictly necessary to use it. You can rather use this kind of code

```
SEXP myFunction(SEXP data)
{
  // wrap a R SEXP struct with a STK++ RMatrix
  STK::RMatrix<double> mat(data); // if data is not a matrix, an exception is thrown
  // wrap a Rcpp matrix in a STK++ RMatrix
  Rcpp::NumericMatrix rmat(100,20);
  STK::RMatrix<double> mat(rmat);
  // Constructor with given dimension
  RMatrix<double> myData(100, 20);
}
```

The template class `STK::RMatrix` wraps a `Rcpp` matrix which itself wrap the R SEXP structure. You can access directly (and eventually modify) the R data in your application like an usual STK++ array.

The second template class you can use is `STK::RVector` which allows to wrap SEXP struct.

3 Converting STK++ arrays and expressions to R data

Rcpp facilitates data conversion from C++ to R through `Rcpp::wrap`. This function is extended by `rtkore` for STK++ arrays and vectors.

The following example is taken from the `STK::ClusterLauncher` class (in `MixAll` package)

```
Array2D<Real> mean(K, nbVariable), sigma(K, nbVariable);
// get estimated parameters
// ....
// and save them
NumericVector m_mean = Rcpp::wrap(mean);
NumericVector m_sigma = Rcpp::wrap(sigma);
```

Note that the `Rcpp::wrap` is rather limited in its usage and if you need, for example, to convert expression rather than arrays then you can use the `STK::wrap` function (see example below).

4 Using rtkore random number generators

All the random numbers of R are interfaced in `rtkore`. You can use them as STK++ random number generators like in the following example

```
RcppExport SEXP fastBetaRand( SEXP n, SEXP alpha, SEXP beta)
{
  BEGIN_RCPP;
  // create a STK++ RVector
  STK::RVector<double> tab(Rcpp::as<int>(n));
  // Create a Beta distribution function with alpha and beta as parameters
  STK::Law::Beta law(Rcpp::as<double>(alpha), Rcpp::as<double>(beta));
  // fill tab with random numbers
  tab.rand(law);
  // return the wrapped Rcpp vector
  return tab.vector();
  END_RCPP;
}
```

5 Linking with rtkore

At the R level, you have to add the `LinkingTo: rtkore,Rcpp` line in the `DESCRIPTION` file.

At the C++ level, the only thing to do is to include the header file

```
// Rcpp.h will be include by rtkore
#include <RTKpp.h>
```

in the C++ code.

When compiling the sources, you indicate the location of the `stk++` library using `rtkore:::CxxFlags()`, `rtkore:::CppFlags()` and `rtkore:::LdFlags()` in the `src/Makevars` file.

A minimal `Makevars` would look like

```
PKG_CXXFLAGS = `${R_HOME}/bin/Rscript -e "rtkore:::CxxFlags()"`
PKG_CPPFLAGS = `${R_HOME}/bin/Rscript -e "rtkore:::CppFlags()"` ${SHLIB_OPENMP_CXXFLAGS}
PKG_LIBS      = `${R_HOME}/bin/Rscript -e "rtkore:::LdFlags()"` \
                ${SHLIB_OPENMP_CFLAGS} ${LAPACK_LIBS} ${BLAS_LIBS} ${FLIBS}
```

6 Building huge package using rtkore

If you are building a package with a lot of `cpp` files, you may find convenient to locate your sources in a separate directory. Hereafter we give an example of a `Makevars` you can modify at your convenience in order to handle this situation.

```
#-----
# Purpose: Makevars for the R packages using rtkore (stk++)
#-----
PKGNAME = NAME_OF_YOUR_SRC # for example MyPackage
```

```

PKGDIR      = PATH_TO_YOUR_SRC # for example ./MyPackage
PKGLIBDIR   = $(PKGDIR)/lib    # ./MyPackage/lib
PKGLIB      = $(PKGLIBDIR)/lib$(PKGNAME).a # ./MyPackage/lib/libMyPackage.a

## Use the R_HOME indirection to support installations of multiple R version.
PKG_CXXFLAGS = `${R_HOME}/bin/Rscript -e "rtkore:::CxxFlags()"`
PKG_CPPFLAGS = `${R_HOME}/bin/Rscript -e "rtkore:::CppFlags()"` \
                $(SHLIB_OPENMP_CXXFLAGS)

## We link the source in the src/ directory with the stkpp library and libMyPackage.a
## use $(SHLIB_OPENMP_CFLAGS) as stkpp use openMP
## use $(LAPACK_LIBS) $(BLAS_LIBS) $(FLIBS) if you want to use lapack and/or stk++
## wrappers of lapack
PKG_LIBS = `${R_HOME}/bin/Rscript -e "rtkore:::LdFlags()"` $(PKGLIB) \
           $(SHLIB_OPENMP_CFLAGS) \
           $(LAPACK_LIBS) $(BLAS_LIBS) $(FLIBS)

## Define any flags you may need for compiling your sources and export them
MY_CXXFLAGS = $(PKG_CXXFLAGS)
MY_CPPFLAGS = $(PKG_CPPFLAGS)

export

.PHONY: all pkglib

## $(SHLIB) is the usual default target that is built automatically from all source
## files in this directory. pkglib is an additional target for the package
## that will be found in $(PKGDIR).
all: $(SHLIB)
$(SHLIB): pkglib

## build the PKGLIB (lib$(PKGNAME).a)
pkglib:
(cd $(PKGDIR) && $(MAKE) all)
(cd $(PKGDIR) && $(MAKE) clean)

```

7 An example

The package `countMissings` is basically composed of one R-script file (`countNA.R`) and one C++ file (`countNA.cpp`).

Given a R matrix, you get a list composed of two vectors containing respectively the number of missing values in each rows and each columns of the R matrix.

The R-script `countNA.R` is essentially

```

countNA <- function(data)
{
  if (!is.matrix(data)) { stop("in countNA, data must be a matrix.")}
  .Call("countNA", data, PACKAGE = "countMissings")
}

```

and the C++ files is

```

#include "RTKpp.h"
RcppExport SEXP countNA( SEXP r_matrix)
{
  BEGIN_RCPP
  STK::RMatrix<double> m_data(r_matrix);
  // use STK::wrap function (Rcpp::wrap function will not work)
  return Rcpp::List::create( Rcpp::Named("rows")= STK::wrap(STK::countByRow(m_data.isNA()))
                           , Rcpp::Named("cols")= STK::wrap(STK::count(m_data.isNA()))
                           );
  END_RCPP
}

```

References

- [1] E. Anderson, Z. Bai, C. Bischof, S. Blackford, J. Demmel, J. Dongarra, J. Du Croz, A. Greenbaum, S. Hammarling, A. McKenney, and D. Sorensen. *LAPACK Users' Guide*. Society for Industrial and Applied Mathematics, Philadelphia, PA, third edition, 1999.
- [2] Douglas Bates and Dirk Eddelbuettel. Fast and elegant numerical linear algebra using the RcppEigen package. *Journal of Statistical Software*, 52(5):1–24, 2013.
- [3] Douglas Bates, Romain François, and Dirk Eddelbuettel. *RcppEigen: Rcpp integration for the Eigen templated linear algebra library*, 2014. R package version 0.3.2.0.2.
- [4] Romain François, Dirk Eddelbuettel, and Douglas Bates. *RcppArmadillo: Rcpp integration for Armadillo templated linear algebra library*, 2014. R package version 0.4.000.2.
- [5] Quentin Grimonprez. *HDPenReg: High-Dimensional Penalized Regression*, 2015. R package version 0.91.
- [6] Serge Iovleff. *Clustering With MixAll*, 2015. R package version 1.0.2.
- [7] Parmeet Singh Bhatia, Serge Iovleff, and Gérard Govaert. blockcluster: An R package for model-based co-clustering. *Journal of Statistical Software*, 76(9):1–24, 2017.