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 functionnalities 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] 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. The `rtkpp` package is also available and provides the header files composing the whole `STK++` library. Theses packages furnish 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     8
```

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)
{
  STK::RMatrix<double> mat(data); // if data is not a matrix, Rcpp will throw an exception
  // ....
  // wrap a Rcpp matrix in a STK++ matrix
  Rcpp::NumericMatrix rmat(100,20);
  STK::RMatrix<double> mat(rmat);      // wrap
  // Constructor with given dimension
  RMatrix<double> myData(100, 20);
  // Copy constructor
  RMatrix<double> myCopy(mat)
}
```

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 `Rcpp::Vector` class.

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 (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 used 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)
```

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)
```

6 An example

The package countMissings can be downloaded at the `http://sourceforge.net/projects/stkpp/files/R%20packages/countMissings_1.0.tar.gz/download` url. It is basically composed of one R-script file (countNA.R) and one C++ file (countNA.cpp).

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