The C++ coding standard of SAND

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Abstract
We have now the honor to submit to the consideration of the SAND group in Σ assembled, that C++ coding standard which has appeared to us the most advisable.
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1 Naming conventions

Use descriptive names. Names with a short scope can have shorter names, but all names with global or template scopes should have longer descriptive names.

1.1 Files and directories
Files and directories shall always have names in lowercase letters which should reflect the name of the class it contains. The file extensions are .cpp and .h for source and header files, respectively.

/parser/fileparser.cpp
/parser/fileparser.h

1.2 Namespaces
Namespaces shall have names starting with an uppercase letter. If the name of the namespace contains of several words each should word should begin with an uppercase letter. Don’t use underscores in namespace names.

namespace NRlib {
    
    double NormalPDF(double mean, double var);
}

void MyFunc() {
    double p = NRlib::NormalPDF(0, 2);
}

1.3 Classes
Classes should be named in the same way as namespaces.

1.4 Functions
Functions should be named in the same way as namespaces.

int Max(int a, int b);

void MyFunc() {
    int c = Max(2, 5);
}

1.5 Variables
Variables should be lowercase with words separated by underscores.

int count_iterations = 0;

Variable names should reflect what the variable is. For example i, j and k should only be used for integers. While f and g typically are floats.

1.6 Class member variables
Class member variables should end with an underscore.
class MyClass {
    public:
        int GetSize() const;
    protected:
        void SetSize(int size);
    private:
        int size_;
    }

    MyClass::SetSize(int size) {
        size_ = size;
    }

1.7 Enumerators
Enumerators should be uppercase with words separated by underscores.

    enum {LOWERCASE_LETTER, UPPERCASE_LETTER};

1.8 Constants
Constants should be uppercase with words separated by underscores.

    const double PI = 3.14159265358979323846;

1.9 Macros
Please don’t use preprocessor macros unless strictly it is necessary. In most cases templates, inline functions or constants can be used instead, giving type safety, and making it easier to debug.

    #define MAC_MY_DEBUG 1
    
    
    
    #ifdef MAC_MY_DEBUG
        assert(i > 0);
    #endif

2 Formatting

2.1 Indents
Each scope should be indented with two spaces. The editor should be configured in such a way that it only inserts spaces, since tabs can be visualised with variable width on different platforms.

    int main() {
        int i;
        for (int i = 0; i < 100; ++i) {
            if (i % 2 != 0) {
                std::cout << i << " is odd\n";
2.2 Line length
Line length should not exceed 79 characters, and overflowing lines should be aligned accordingly.

```cpp
int MyClass::MyFunction(const MyType&
    this_is_a_very_long_variable_name,
    int n_iter,
    MyType& another_variable) { }
```

2.3 Spacing
Use spacing in such a way that the code becomes easy to read.

The following rules should be obeyed:

- No space before a ‘;’:
  ```cpp
  std::cout << i << 'is odd\n';
  ```

- Space before and after operators except the not operator ‘!:
  ```cpp
  if (!(i % 2 == 0)) {
    j = 0.5 * i;
  }
  ```

- But the space before and after operators can be let out to visualise precedence:
  ```cpp
  a = b + c*d;
  Instead of:
  a = b + c * d;
  ```

- No space after '(' or before ')
  ```cpp
  if ((i == 1) && (j == 0))
  ```

- Make two empty lines after a function definition.
  ```cpp
  void MyClass::SetVal(int val) {
    val_ = val;
  }
  ```

  ```cpp
  int MyClass::GetVal() const {
    return val_;  
  }
  ```
2.4 Brackets
Rules for placing of brackets:

- Always put ‘}’ on a separate line, while ‘{’ shall be on the end of a line:

```cpp
if (i == 1) {
    :
} else {
    :
}
```

- Always enclose nested statements in brackets:

```cpp
for (int i = 0; i < len_; ++i) {
    if (val_[i] > max) {
        max = val_[i];
    }
}
```

3 Classes

3.1 Member variables
Member variables should either be defined as protected, or preferably private. If for some reason most or all member variables should be public, the struct keyword should be used instead of the class keyword.

3.2 Accessors
- Use functions whose names start with get and set for access of class members:

```cpp
class MyClass {
    public:
        .
        .
        .
        int GetValue() const;
        void SetValue(int val);

    private:
        .
        int val_;
}
```

```cpp
void MyFunc() {
    MyClass object;
    :
    if (object.GetValue() == 0) {
        object.SetValue(42);
    }
}
```
- Use an overloaded []-operator for access of data from an one-dimensional datastructure. Both a const-version, and a version that can be used to change data should be provided.

    ```
    class Well {
    public:
       
       const double operator[](int i) const;
       double& operator[](int i);
    
    private:
       std::vector<double> log_;  
    }
    
    void MyFunc() {
       Well my_well;  
       
       if (my_well[i] == 0) {
          my_well[i] = my_well[i - 1];
       }
    }
    ```

- Use an overloaded ()-operator for access of multi-dimensional data. Both a const-version, and a version that can be used to change data should be provided.

    ```
    class Grid {
    public:
       
       const double operator()(int i, int j, int k) const;
       double& operator()(int i, int j, int k);
    
    }
    
    void MyFunc() {
       Grid grid;  
       
       if (grid(i, j, k) < 0) {
          grid(i, j, k) = grid(i, j, k - 1);
       }
    }
    ```

### 3.3 Const functions

All member functions that does not alter member variables should be labeled const. This is important so that the functions can be used on const objects, and it also helps documenting the how the function works.

    ```
    class MyClass {
       
       int GetValue() const;
    ```
3.4 Lazy evaluation of class members

In some cases a class can have a member which takes long time to compute. In this case it might be feasible to wait with computing the member until it is really needed. In such cases we can get an accessor function that is logically const, but that calculates the member value the first time it is called. In such cases the accessor function should be const, and member variable should be declared mutable.

class MyClass {
public:
    double GetVar() const;
private:
    // Only evaluated when needed.
    mutable double var_;  // Must be mutable.
    bool var_evaluated_;  // Must be declared.
}

MyClass::getVar() {
    if (var_evaluated_) {
        return var_;  // Must be const.
    } else {
        var_ = CalculeVar();
    }
}

The same effect can also be achieved by casting away the const-ness of the object, but this is not guaranteed to give a predictable result in cases where the object was originally defined as a const.

3.5 Rule of 3

When a class needs a special copy constructor, an copy assignment operator or a destructor it usually needs all three. This is typically the case if the class handles some resources like allocated memory, files, etc. If the copy assignment operator or the copy constructor is not implemented, meaning that it should not be possible to make a copy of a object of the class, a copy constructor and/or copy assignment operator definition should be declared as private for the class to prevent use of the default copy constructor and/or copy assignment operator.

class MyClass {
public:
    MyClass(int size);
    ~MyClass();
private:
    double* data;

    // Not implemented.
    MyClass(const MyClass& obj);    // Must be private.
    MyClass& operator=(const MyClass& obj);    // Must be private.
}
MyClass::MyClass(int size) {
    data = new double[size];
}

MyClass::~MyClass() {
    delete [] data;
}

### 3.6 Ordering of class members

The access levels should be ordered in the following way:

1. public class members.
2. protected class members.
3. private class members.

The public interface should come first in a class definition, thereafter the protected interface, that is needed to develop sub-classes. The private section containing implementation details should come last.

For each access level the functions and member data should be given in the following order:

1. Friend classes.
2. Constructors.
3. Copy constructor.
4. Destructor.
5. Overloaded operators.
6. Accessor functions. (Get and set functions)
7. General functions.
8. Friend functions.
9. Member variables.

Friend classes should in most cases be avoided.

The order of the class members in the implementation (.cpp-file) shall be the same as in the header file.

class Well {
public:
    friend WellTransform;
    Well(int len);
    Well(const Well& well);
    ~Well();
    const double operator[](int index) const;
    double& operator[](int index);
    int GetLength() const;
    void DoSomethingWithWell();
}
friend void SmoothWell(Well& well);

protected:
    Well();
    void resize(int new_len);

private:
    void DoSomeVectorTrick();
    int len_
    std::vector<double> log_
};

3.7 Variable initialisation in constructors

Variables should be initialised in the constructor instead of being assigned in the constructor body. If a special version of the constructor for the parent class should be called, this is done in a similar fashion:

class Grid {
public:
    Grid(int nx, int ny, int nz);
private:
    int nx_
    int ny_
    int nz_
    std::vector<double> values_
};

Grid::Grid(int nx, int ny, int nz)
    : nx_(nx),
    ny_(ny),
    nz_(nz) {}

class StormGrid : public Grid {
public:
    StormGrid(int nx, int ny, int nz, double missing_val);
private:
    double missing_val_
};

StormGrid::StormGrid(int nx, int ny, int nz, double missing_val)
    : Grid(nx, ny, nz),
    missing_val_(missing_val) {}

4 Types

4.1 Integer types

int should be used as the default integer type.

For specific uses as for example size of an object or time representation the built in types for
example size_t, time_t should be used.

```cpp
vector<int> vec(100);
size_t vec_size = vec.size();
time_t now = time(NULL);
```

### 4.2 Literals
Use the upper-case suffixes ‘U’, ‘UL’ and ‘L’ for unsigned int, unsigned long and long integer literals. Use the upper-case suffixes ‘F’ and ‘L’ for float and long double floating-point literals.

```cpp
const int MY_CONST = 42;
const double PI = 3.14159265358979323846;
const float PI_F = 3.14159265F;
const long double PI_L = 3.1415926535897932384626433832795029L;
const unsigned int len = 192U;
const long long_len = 1024L;
```

### 4.3 Placement of * and &
Place the * or & after right after type when declaring reference or pointer types. Place right in front of variable name when dereferencing or taking reference of a variable.

```cpp
void MyFunc(const int& my_int) {
    int* my_int_pointer = &my_int;
    int another_int = *my_int_pointer;
}
```

### 4.4 Function parameters
Big objects should be given as constant reference arguments. All reference or pointer arguments shall be declared const if they are not modified.

```cpp
int CalculateSize(const BigObject& obj) {
    return obj.GetSize();
}
```

### 5 General coding style

#### 5.1 Declare local variables when used
Local variables should be declared when they are first used.

```cpp
void MyFunc {
    .
    .
    int i = 0;
    while (well[i] == 0) {
        ++i;
    }
    .
    .
}
```
5.2 Importing the std namespace into global namespace

Be careful with importing the std namespace using `using namespace std` directives. Often it is better to use the complete name, including the namespace. `using` directives if used should only be used in cpp-files, *never* in h-files.

5.2.1 Using full names

```cpp
int main() {
    std::cout << "Hello World!\n";
}
```

5.2.2 Importing only a single function

```cpp
using std::cout;
int main() {
    cout << "Hello World!\n";
}
```

5.2.3 Importing the complete std namespace

```cpp
using namespace std;
int main() {
    cout << "Hello World!\n";
}
```

5.3 Import namespaces locally when needed

```cpp
// Get access to NRlib utilities throughout
using namespace NRlib::Util;
int main(unsigned int argc, char* argv[]) {

    // Begin scoping bracket

    // Get access to NRlib User Interface namespace
    using namespace NRlib::UI;

    Program& program =
    Singleton<Program>::Instance();

    program.Initialize("Demo program", // Name
                      0, // Major version
                      1, // Minor version
                      0, // Patch number
                      "Testing", // Purpose.
                      "Demo of NRlib", // Program description
                      2005, // First year copyright
                      "Norwegian Computing Center" // Copyright holder
                      );

    Options& options =
    Singleton<Options>::Instance();
    options.Initialize();
    options.Read(argc, argv);
```
5.4 Memory management

- new and delete should always be used for memory management instead of C-style malloc and free.

- Whenever possible allocate memory on the stack instead of on the heap. This makes it easier to prevent memory leaks, for example when an exception is thrown.

Use:
void ModifyGrid(Grid* grid);

void MyFunc() {
    Grid grid(nx, ny, nz);
    ModifyGrid(&grid);
}

Instead of:
void ModifyGrid(Grid* grid);

void MyFunc() {
    Grid* grid = new Grid(nx, ny, nz);
    ModifyGrid(grid);
    delete grid;
}

If ModifyGrid in the previous examples throws an exception, this would result in a memory leak in the last case where new and delete was used.

5.5 Definition of index in for-loops

The iterator index for a for-loop should always be defined before the start of the for-loop.

The reason for this is that although the scope of the iterator index is clearly defined in the C++-standard to be inside the for-loop, some compilers among them Visual C++ puts the iterator index in the parent scope.

Use:
int i;
for (i = 0; i < len; ++i) {
    values[i] = 0;
}

Instead of:
for (int i = 0; i < len; ++i) {
    values[i] = 0;
}
5.6 Increment operator
Do not use ++i or i++ in complex statements, since it makes it much more difficult to see what a statement does. If used in the statement the behaviour should be documented.

Use:

```
++i;
my_list[i] = 0;
```

Instead of:

```
my_list[++i] = 0;
```

For complex datatypes the prefix operator ++i should be used instead of i++, since it can be implemented more efficiently since the previous value is not stored.

5.7 Iterators
For containers like vectors and lists iterators should be used instead of indexes, since they often give more efficient code that indexes, and since it makes it easier to replace the container.

```
void Init(std::vector<int> values) {
    std::vector<int>::iterator it;
    for (it = values.begin(); it != values.end(); ++it) {
        *it = 0;
    }
}
```

5.8 Expressions inside function calls
Be careful with expressions inside function calls to functions that take more than one argument. The order of evaluation of the parameters is dependent on the compilator.

**DO NOT DO THIS:**

```cpp
int F(int i, int j) {
    return i % j;
}
```

```cpp
void MyFunc() {
    i = 1;
    F(i++, i++);
}
```

In the example above it depends on the compiler if F(2, 3), F(3, 2) or F(3, 3) is evaluated.

For this reason nested function calls like F(G(), H()), should be avoided.

**Do:**

```cpp
double g = G();
double h = H();
double f = F(g, h);
```

**Instead of:**

```cpp
double f = F(G(), H());
```
6 Comments

Good documentation of the code is important, but self-documenting code should not be commented.

6.1 Standard header

All files should start with a standard header giving the author, date, and giving a short description of the file.

// $Id: crava.cpp,v 1.69 2005/10/04 15:58:41 ok Exp $
/** @file
   Implementation of main routines for CRAVA.
   @author Odd Kolbjørnsen, Norsk Regnesentral
   @date 7/9 2004 */

The $Id: ...$ is part is filled out by CVS or Subversion every time the file is checked in. The rest of the comment is formatted so that it can be used to generate documentation by doxygen.

6.2 Documentation of headerfiles

The header file should contain all information needed by users of your class. Use /// or /** */ to make comments available for doxygen. The text up to the first period is a brief description of the object. The rest is for a more detailed description. Please document the input and output parameters and return values of functions, and don’t forget to put your name in the author field. Bugs are bad, but anonymous bugs are even worse!

For more information about doxygen see http://www.doxygen.org.

 /**
  * Root finder.
  * This class is used to find
  * exact solutions of quartic (biquadratic), cubic,
  * and quadratic polynomials with real coefficients.
  * The class is tested in a test program in polynomial_test.c.
  * @author Harald H. Soleng, Norwegian Computing Center */

class Polynomial {
public:
 /**
 Constructor.
 @param[in] coefficients an array of polynomial coefficients.
 @param[in] order the order of the polynomial.
 */
 Polynomial(double* coffecients, unsigned int order);

 /**
 Solver. This command solves the equation.
 @param[out] real components (must be preallocated).
 @param[out] imaginary components (must be preallocated if used).
 By default the imaginary array is a null pointer,
 in which case only real solutions are found.

@return number of solutions.
*/
unsigned int Solve(double* real,
        double* imaginary = 0);

7 The header file

7.1 Include guards
Include-guards shall be used in all header-files. The include-guards should be made up of catalog
name and filename to make sure that it is unique.

#ifndef NRLIB_POLYGON_H
#define NRLIB_POLYGON_H

// Header-file code

#endif // NRLIB_POLYGON_H

In Visual Studio #pragma once does the same thing, but this is not portable.

7.2 Forward declarations and includes
To avoid needless compile-time dependencies avoid the use of includes in header files whenever
possible. It is often sufficient to enter a forward declaration, e.g., class Polynomial in the header
file and use the include statement in the source file. This being said, don’t try do declare any part
of the Standard Template Library (STL). For streams use the forward declaration file iosfwd.

class Point;

class Line {
    public:
        Line(Point from, Point to);
    private:
        Point from_;        
        Point to_;        
}

8 Error handling

Exceptions should be used for error handling inside library code. All exceptions should implement
a function what() that describes the exception. All exception should directly or indirectly be a
subclass of std::exception.

namespace NRlib {
    namespace Util {
        class Exception : public std::exception {
            public:

```
Exception(const std::string& msg = "")
: msg_(msg) {}

std::string what() const {
    return msg_;}
private:
    std::string msg_;}

class FileIOError : public Exception {
public:
    FileIOError(const std::string& msg = "") : NRlib::Exception(msg);
};

void FileParser::OpenFile(std::string filename) {
    fin_ = new std::ifstream(filename.c_str());
    if (!fin) throw NRlib::Util::FileIOError("Error opening file " + filename);
}

void MyFunc() {
    try {
        FileParser parser;
        parser.OpenFile(filename);
    } catch (NRlib::Util::Exception e) {
        std::cerr << "Exception occured when opening file: " << e.what()
        << std::endl;
        std::abort();
    } catch (std::exception e) {
        std::cerr << "A non-nrlib exception occured: " << e.what()
        << std::endl;
        std::abort();
    }
}
```

### 9 Standard tools

#### 9.1 Version control

A version control system should be used in all larger projects. In internal projects either CVS or subversion should be used.

A file checked out with a CVS or subversion client for Windows should not be edited from UNIX and visa versa. UNIX and Windows has different standards for line shifts, and the clients are able to translate between different version so that files checked out on Windows has Windows line-shifts, while files checked out on UNIX has UNIX line-shifts.
9.2 Tools for detection of memory bugs
All production code should be run through a tool checking for memory bugs and memory leaks.
Two such programs that are available at Sand are Purify and Valgrind.
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