OOMMF
Programming Manual

October 30, 2002

This manual documents release 1.2a3.

WARNING: In this alpha release, the documentation may not be up to date.

WARNING: This document in under construction.

Abstract

This manual provides source code level information on OOMMF (Object Oriented Micromagnetic Framework), a public domain micromagnetics program developed at the National Institute of Standards and Technology. Refer to the OOMMF User's Guide for an overview of the project and end-user details.

Contents

Disclaimer

We would appreciate acknowledgement if the software is used. When referencing OOMMF software, we recommend citing the NIST technical report, M. J. Donahue and D. G. Porter, "OOMMF User's Guide, Version 1.0," **NISTIR 6376**, National Institute of Standards and Technology, Gaithersburg, MD (Sept 1999).

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1 Programming Overview of OOMMF

The OOMMF[1] (Object Oriented Micromagnetic Framework) project in the Information Technology Laboratory (ITL) at the National Institute of Standards and Technology (NIST) is intended to develop a portable, extensible public domain micromagnetic program and associated tools. This manual aims to document the programming interfaces to OOMMF at the source code level. The main developers of this code are Mike Donahue and Don Porter.

The underlying numerical engine for OOMMF is written in C++, which provides a reasonable compromise with respect to efficiency, functionality, availability and portability. The interface and glue code is written primarily in Tcl/Tk, which hides most platform specific issues. Tcl and Tk are available for free download [2] from the Tcl Developer Xchange[3].

The code may actually be modified at 3 distinct levels. At the top level, individual programs interact via well-defined protocols across network sockets. One may connect these modules together in various ways from the user interface, and new modules speaking the same protocol can be transparently added. The second level of modification is at the Tcl/Tk script level. Some modules allow Tcl/Tk scripts to be imported and executed at run time, and the top level scripts are relatively easy to modify or replace. The lowest level is the C++ source code. The OOMMF extensible solver, OXS, is designed with modification at this level in mind.

If you want to receive e-mail notification of updates to this project, register your e-mail address with the "μMAG Announcement" mailing list:

http://www.ctcms.nist.gov/~rdm/email-list.html.

The OOMMF developers are always interested in your comments about OOMMF. See the Credits (Sec. 5) for instructions on how to contact them.

[1] http://math.nist.gov/oommf/
[2] http://purl.org/tcl/home/software/tcltk/choose.html
[3] http://purl.org/tcl/home/

2 Platform-Independent Make

UNDER CONSTRUCTION

Details on pimake go here.

Somewhere we should have documentation on feeding and breeding makerules.tcl files. Should that be here, or in a separate section? If the former, then should this section be renamed?

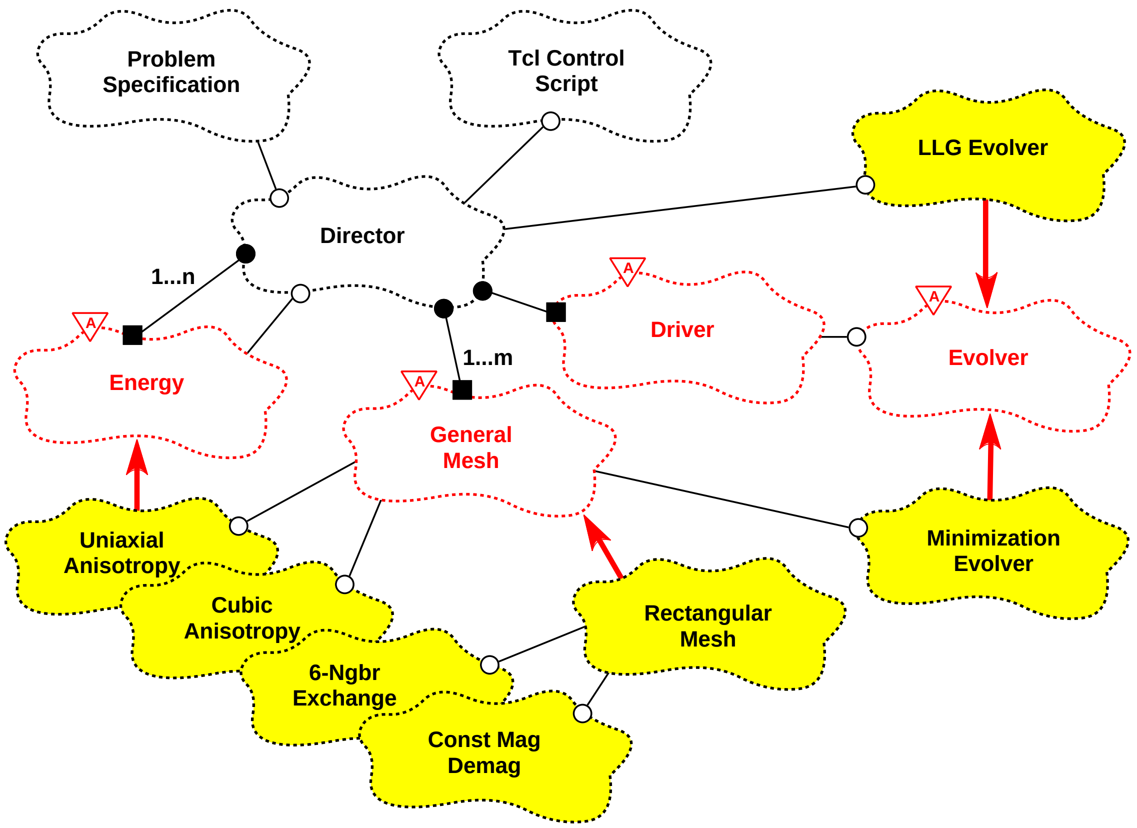

Figure 1: OXS top-level class diagram.

3 OOMMF eXtensible Solver

The OOMMF eXtensible Solver (OXS) top level architecture is shown in Fig. 1. The "Tcl Control Script" block represents the user interface and associated control code, which is written in Tcl. The micromagnetic problem input file is the content of the "Problem Specification" block. The input file should be a valid MIF 2.0 file (see the OOMMF User's Guide for details on the MIF file formats), which also happens to be a valid Tcl script. The rest of the architecture diagram represents C++ classes.

All interactions between the Tcl script level and the core solver are routed through the Director object. Aside from the Director, all other classes in this diagram are examples of `Oxs_Ext` objects—technically, C++ child classes of the abstract `Oxs_Ext` class. OXS is designed to be extended primarily by the addition of new `Oxs_Ext` child classes.

The general steps involved in adding an `Oxs_Ext` child class to OXS are:

1. Add new source code files to `oommf/app/oxs/local` containing your class definitions. The C++ non-header source code file(s) must be given the `.cc` extension. (Header files are typically denoted with the `.h` extension, but this is not mandatory.)

2. Run **pimake** to compile your new code and link it in to the OXS executable.

3. Add the appropriate `Specify` blocks to your input MIF 2.0 files.

The source code can usually be modeled after an existing `Oxs_Ext` object. Refer to the Oxsii section of the OOMMF User's Guide for a description of the standard `Oxs_Ext` classes, or Sec. 3.1 for an annotated example of an `Oxs_Energy` class. Base details on adding a new energy term are presented in Sec. 3.2.

The **pimake** application automatically detects all files in the `oommf/app/oxs/local` directory with the `.cc` extension, and searches them for `#include` requests to construct a build dependency tree. Then **pimake** compiles and links them together with the rest of the OXS files into the **oxs** executable. Because of the automatic file detection, no modifications are required to any files of the standard OOMMF distribution in order to add local extensions.

Local extensions are then activated by `Specify` requests in the input MIF 2.0 files. The object name prefix in the `Specify` block is the same as the C++ class name. All `Oxs_Ext` classes in the standard distribution are distinguished by an `Oxs_` prefix. It is recommended that local extensions use a local prefix to avoid name collisions with standard OXS objects. (C++ namespaces are not currently used in OOMMF for compatibility with some older C++compilers.) The `Specify` block initialization string format is defined by the `Oxs_Ext` child class itself; therefore, as the extension writer, you may choose any format that is convenient. However, it is recommended that you follow the conventions laid out in the MIF 2.0 file format section of the OOMMF User's Guide.

3.1 Sample `Oxs_Energy` Class

This sections provides an extended dissection of a simple `Oxs_Energy` child class. The computational details are kept as simple as possible, so the discussion can focus on the C++class structural details. Although the calculation details will vary between energy terms, the class structure issues discussed here apply across the board to all energy terms.

The particular example presented here is for simulating uniaxial magneto-crystalline energy, with a single anisotropy constant, `K1`, and a single axis, `axis`, which are uniform across the sample. The class definition (.h) and code (.cc) are displayed in Fig. 2 and 3, respectively.

```
/* FILE: exampleanisotropy.h
 *
 * Example anisotropy class definition.
 * This class is derived from the Oxs_Energy class.
 *
 */

#ifndef _OXS_EXAMPLEANISOTROPY
#define _OXS_EXAMPLEANISOTROPY
```

```
#include "energy.h"
#include "threevector.h"
#include "meshvalue.h"

/* End includes */

class Oxs_ExampleAnisotropy:public Oxs_Energy {
private:
  double K1;        // Primary anisotropy coeficient
  ThreeVector axis; // Anisotropy direction
public:
  virtual const char* ClassName() const; // ClassName() is
  /// automatically generated by the OXS_EXT_REGISTER macro.
  virtual BOOL Init();
  Oxs_ExampleAnisotropy(const char* name,  // Child instance id
Oxs_Director* newdtr, // App director
Tcl_Interp* safe_interp, // Safe interpreter
const char* argstr);  // MIF input block parameters

  virtual ~Oxs_ExampleAnisotropy() {}

  virtual void GetEnergyAndField(const Oxs_SimState& state,
                                 Oxs_MeshValue<REAL8m>& energy,
                                 Oxs_MeshValue<ThreeVector>& field
                                 ) const;
};


#endif // _OXS_EXAMPLEANISOTROPY
```

Figure 2: Example energy class definition.

```
/* FILE: exampleanisotropy.cc            -*-Mode: c++-*-
 *
 * Example anisotropy class implementation.
 * This class is derived from the Oxs_Energy class.
 *
 */

#include "exampleanisotropy.h"
```

```
// Oxs_Ext registration support
OXS_EXT_REGISTER(Oxs_ExampleAnisotropy);

/* End includes */

#define MU0           12.566370614359172953850e-7   /* 4 PI 10^7 */

// Constructor
Oxs_ExampleAnisotropy::Oxs_ExampleAnisotropy(
  const char* name,     // Child instance id
  Oxs_Director* newdtr, // App director
  Tcl_Interp* safe_interp, // Safe interpreter
  const char* argstr)   // MIF input block parameters
  : Oxs_Energy(name,newdtr,safe_interp,argstr)
{
  // Process arguments
  K1=GetRealInitValue("K1");
  axis=GetThreeVectorInitValue("axis");
  VerifyAllInitArgsUsed();
}

BOOL Oxs_ExampleAnisotropy::Init()
{ return 1; }

void Oxs_ExampleAnisotropy::GetEnergyAndField
(const Oxs_SimState& state,
 Oxs_MeshValue<REAL8m>& energy,
 Oxs_MeshValue<ThreeVector>& field
 ) const
{
  const Oxs_MeshValue<REAL8m>& Ms_inverse = *(state.Ms_inverse);
  const Oxs_MeshValue<ThreeVector>& spin = state.spin;
  UINT4m size = state.mesh->Size();

  for(UINT4m i=0;i<size;++i) {
    REAL8m field_mult = (2.0/MU0)*K1*Ms_inverse[i];
    if(field_mult==0.0) {
      energy[i]=0.0;
      field[i].Set(0.,0.,0.);
      continue;
    }
```

```
    REAL8m dot = axis*spin[i];
    field[i] = (field_mult*dot) * axis;
    if(K1>0) {
      energy[i] = -K1*(dot*dot-1.0); // Make easy axis zero energy
    } else {
      energy[i] = -K1*dot*dot; // Easy plane is zero energy
    }
  }
}
```

Figure 3: Example energy class code.

3.2 Writing a New Oxs_Energy Extension

Under construction.

4 References

[1] W. F. Brown, Jr., *Micromagnetics* (Krieger, New York, 1978).

[2] M. J. Donahue and D. G. Porter, "OOMMF User's Guide, Version 1.0," Technical Report No. NISTIR 6376, National Institute of Standards and Technology, Gaithersburg, MD (1999) .

5 Credits

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If you have bug reports, contributed code, feature requests, or other comments for the OOMMF developers, please send them in an e-mail message to `<michael.donahue@nist.gov>`.

Index