

# CCTBX: Making Compiled Extensions

Graeme Winter, Diamond Light Source

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## 1 Introduction

Much of the benefit of the hybrid approach to CCTBX (<http://cctbx.sourceforge.net/current/tour.htm> hybrid) is the ability to move computationally expensive steps from Python to C++ relatively straightforwardly. It is however helpful to have an example of how to create C++ extensions and compile these with the existing compilation tools. The aim of this document is to provide this example with a toy example, `toytbx`. Some introductory information is however useful.

Within CCTBX C++ code is made available to Python using the Boost Python framework (<http://www.boost.org/libs/python/doc/>) and compiled with SCons (<http://www.scons.org/>.) Two steps are therefore needed to expose C++ code: writing a wrapper using Boost Python and a SConscript for compilation. Using this `libtbx` does most of the work. In addition it is nice to expose functionality as “pseudo-executable” programs e.g. `toytbx.task` - this is also handled automatically by `libtbx`.

## 2 C++ Code

The following code defines a trivial module which contains a single function, which itself generates a Python list. The code defines a module `toytbx_ext`:

```
#include <boost/python.hpp>
#include <cctype>

namespace toytbx {
    namespace ext {

        static boost::python::list make_list(size_t n)
        {
            boost::python::list result;
            for(size_t i = 0; i < n; i++) {
                result.append(i);
            }
            return result;
        }
    }
}
```

```

    void init_module()
    {
        using namespace boost::python;
        def("make_list", make_list, (arg("size")));
    }

}
} // namespace toytbx::ext

BOOST_PYTHON_MODULE(toytbx_ext)
{
    toytbx::ext::init_module();
}

```

For more functions, extra static methods will be needed, as well as additional `def` statements in the `init_module` method.

### 3 Compilation

To compile the code above, `SCons` is used with `libtbx`. The first step is to define a `SConscript` which states the modules requirements:

```

import libtbx.load_env
Import("env_etc")

env_etc.toytbx_include = libtbx.env.dist_path("toytbx")

if (not env_etc.no_boost_python and hasattr(env_etc, "boost_adaptbx_include")):
    Import("env_no_includes_boost_python_ext")
    env = env_no_includes_boost_python_ext.Clone()
    env_etc.enable_more_warnings(env=env)
    env_etc.include_registry.append(
        env=env,
        paths=[
            env_etc.libtbx_include,
            env_etc.boost_adaptbx_include,
            env_etc.boost_include,
            env_etc.python_include,
            env_etc.toytbx_include])
    env.SharedLibrary(
        target="#lib/toytbx_ext",
        source=["ext.cpp"])

```

This can refer to other compiled modules to ensure dependencies are correctly built. With this file and `ext.cpp` in the `toytbx` directory, accessible to `libtbx.configure`, `libtbx.configure toytbx` may be run, followed by `make`, which will correctly compile the extension module.

## 4 Tidying

This has generated an extension module, however it may be desirable to (i) import this nicely named as e.g. `toytbx` and (ii) add Python code to the module. This is best achieved by adding `__init__.py` to the `toytbx` directory containing:

```
from __future__ import division
try:
    import boost.python
except Exception:
    ext = None
else:
    ext = boost.python.import_ext("toytbx_ext", optional = False)

if not ext is None:
    from toytbx_ext import *
```

As with other code test cases should be written which ensure that the behaviour is correct. In this case, the following test is reasonable:

```
from toytbx import make_list

def tst_toytbx():
    assert(make_list(4) == [j for j in range(4)])
    print 'OK'

if __name__ == '__main__':
    tst_toytbx()
```

After which `cctbx.python tst_toytbx.py` should print 'OK'.

## 5 Command Lines

If a command-line executable is desired once again `libtbx` comes to the rescue. Make a directory within the `toytbx` called `command_line`, and within there `make_list.py`:

```
from toytbx import make_list

def main(args):
    assert(args)
    n = int(args[0])
    print make_list(n)

if __name__ == '__main__':
    import sys
    main(sys.argv[1:])
```

Rerunning `libtbx.configure` and `make` should generate executables allowing:

```
Graemes-MacBook-Pro:toytbx graeme$ toytbx.make_list 10  
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

## **6 Acknowledgements**

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