Wrapping C and C++ Libraries with CastXML

Brad King[1], Bill Hoffman[1], Matt McCormick[1], and Michka Popoff

[1] Kitware, Inc.

SciPy, 2015

Outline

1 Motivation and History
- Wrapping the Insight Toolkit (ITK)
- Generating an Abstract Syntax Tree (AST)
- GCC-XML

2 CastXML Description
- Building
- Invocation

3 SciPy Ecosystem Integration
- pygccxml

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The Insight Toolkit (ITK)

- In 1999, the US National Institute of Health's (NIH) National Library of Medicine (NLM) started a project to support the Visible Human Project.

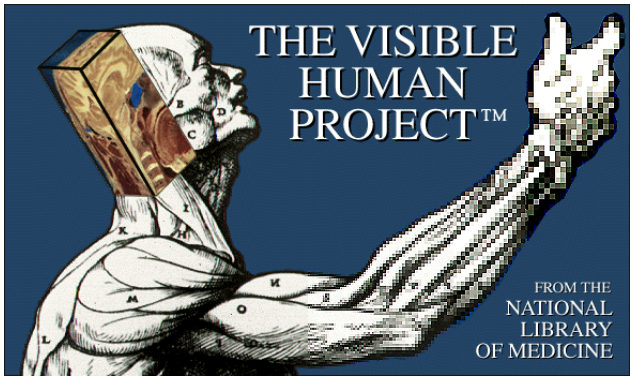
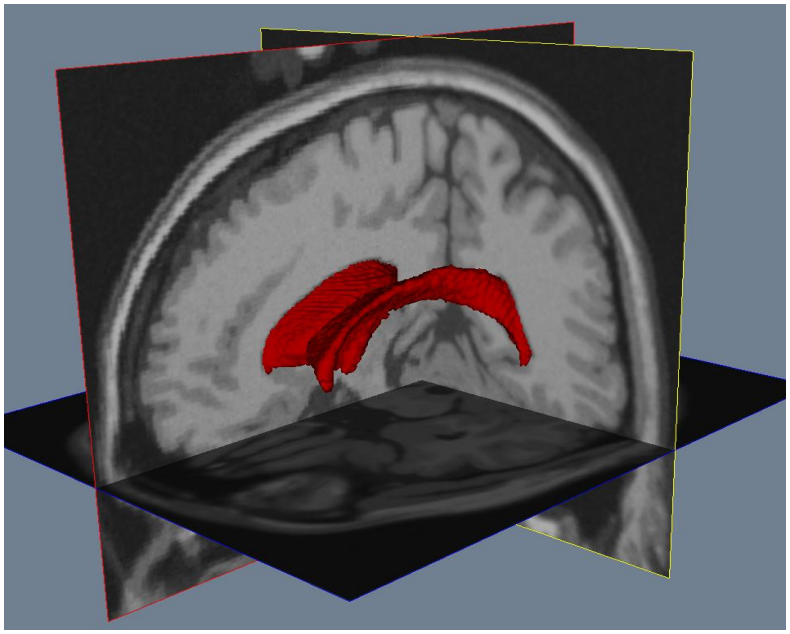


Image Segmentation



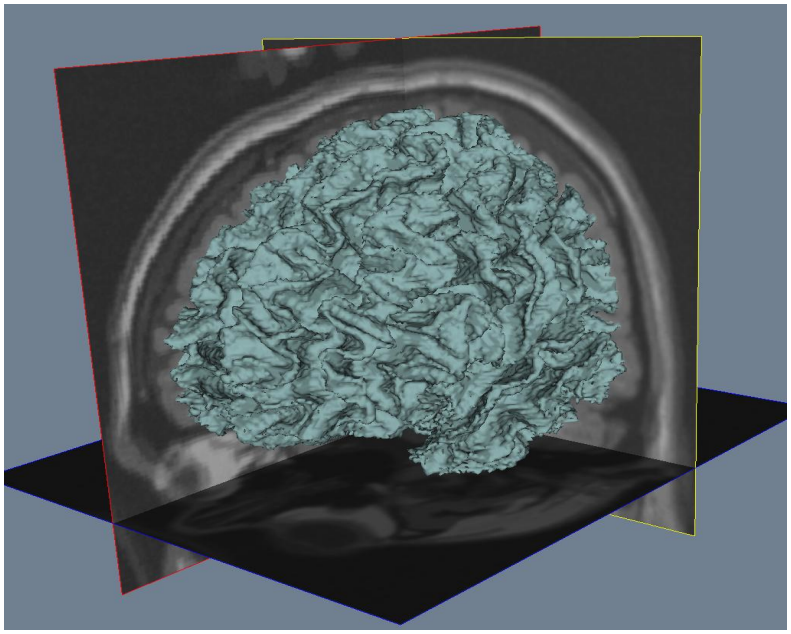
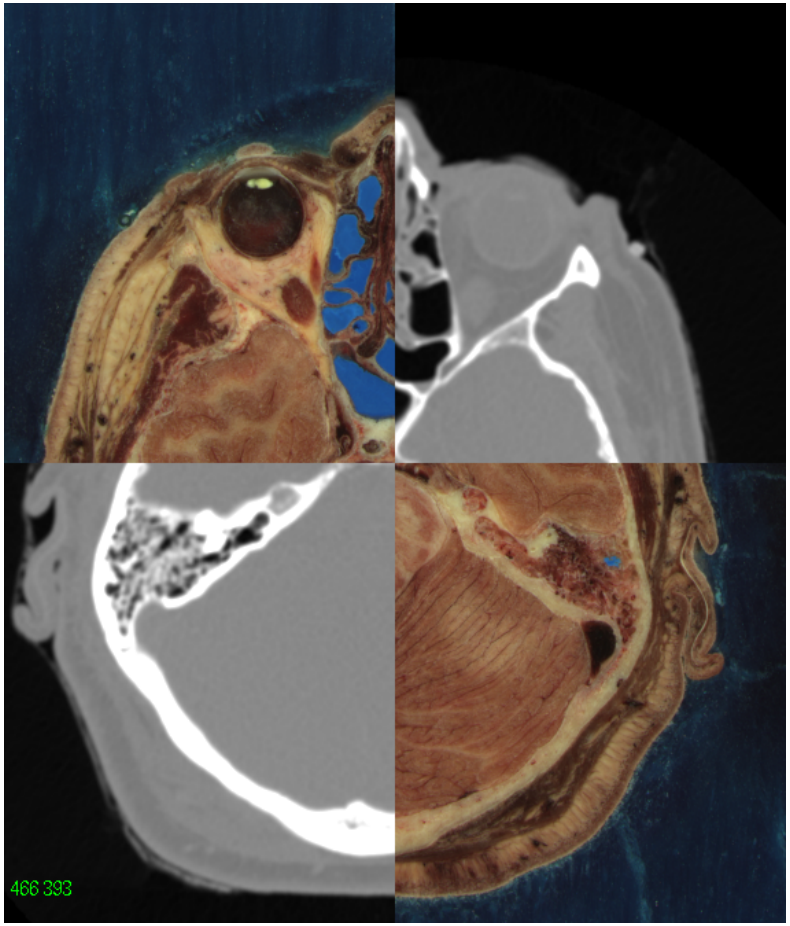
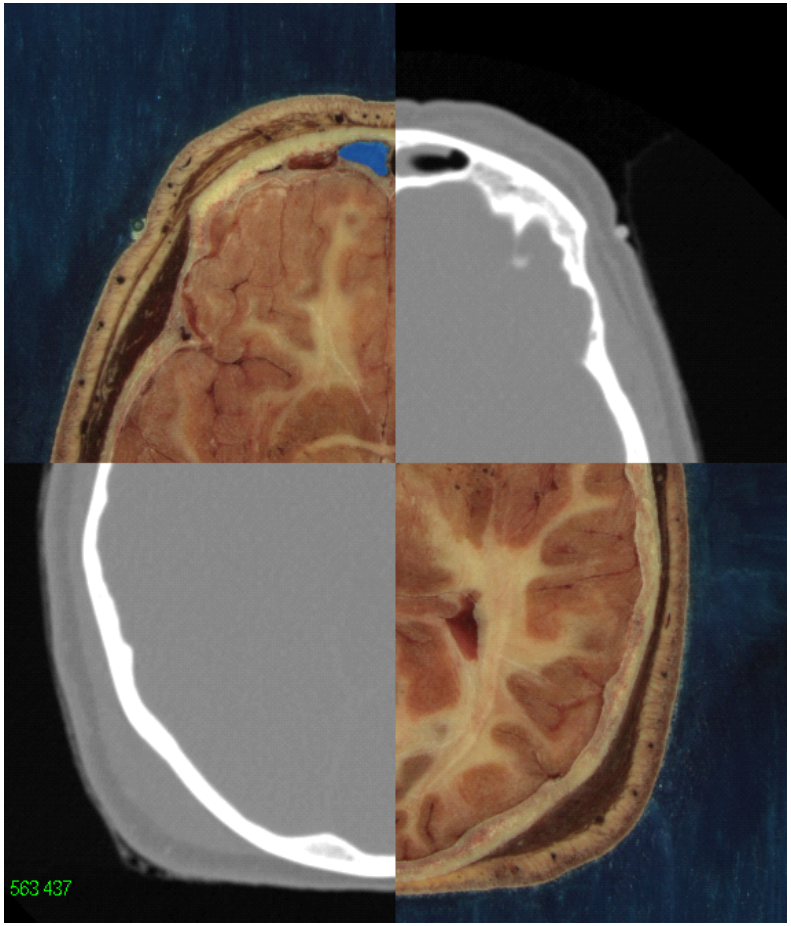


Image Registration





Large C++ Codebase

- Development has progressed since 1999
- Over 1.6 million lines of code
- Highly templated C++

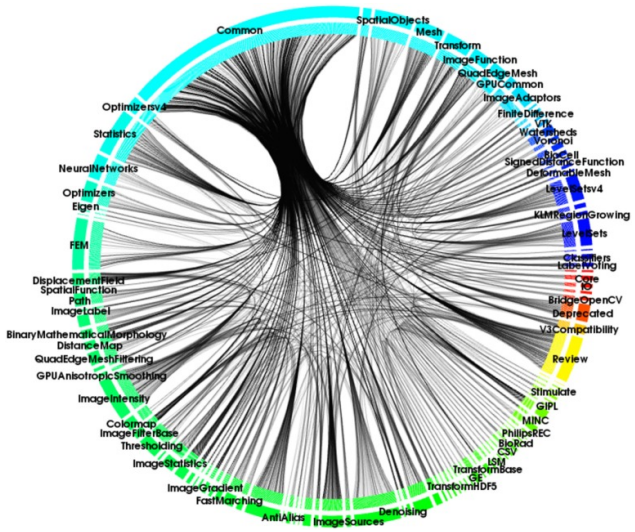


Figure: Visualization of the toolkit modules.

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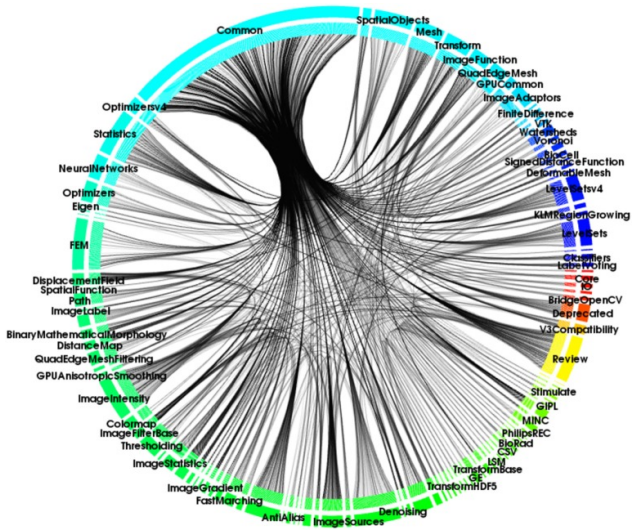

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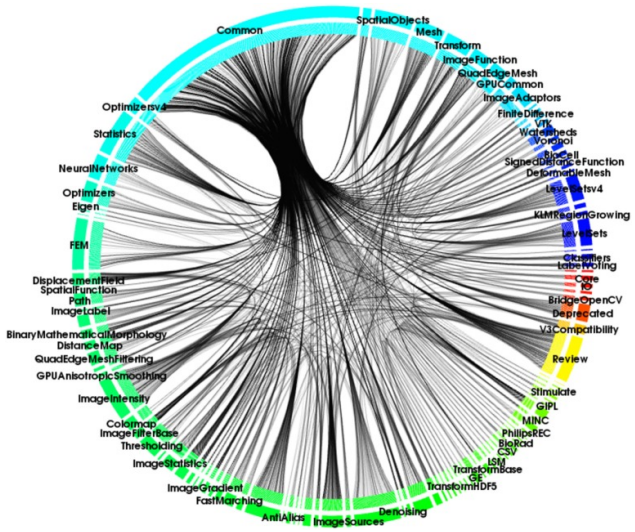

Figure: Visualization of the toolkit modules.

We Want to Use Python!

The most efficient way of 'wrapping' a big library is eating it.

ITK's Wrapping Process

1. Determine an Abstract Syntax Tree (AST) from C++ sources
2. Create Swig `.i` from the AST and desired template parameters
3. Generate CPython extension modules code with Swig
4. Build the extension modules

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C++ Source Code to Abstract Syntax Tree

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namespace MyCoolProject {
  struct test_results {
    enum status {
      ok,
      fail,
      error
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    void update(
      const char * test_name,
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Python Wrappers

AST Generation Complexity

C++ Source Code

- C preprocessor
- Standard library headers (compiler specific)
- Compiler flags

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- Python ctypeslib
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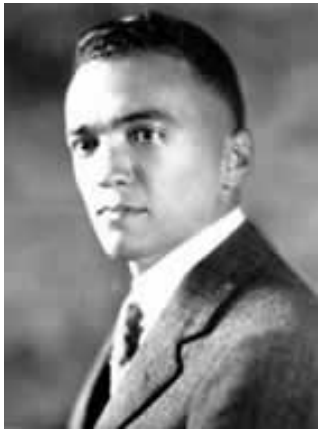

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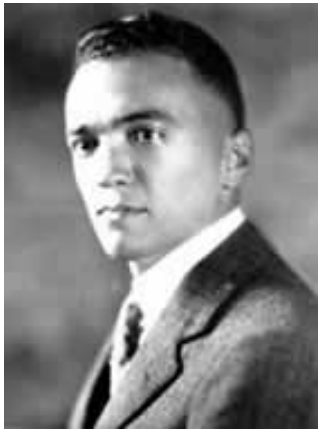

GCC-XML's Weakness

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Maintainability.

CastXML

CastXML is a GCC-XML replacement that uses LLVM/Clang.

CastXML

A **C**-family **a**bstract **s**yntax **t**ree **XML** output tool.

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Invocation

```
castxml \
  --castxml-gccxml \
  --castxml-cc-msvc cl \
  -o ouput.xml
  input.cxx
```

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pygccxml

pygccxml

A specialized XML reader that reads the output from CastXML and GCC-XML. It provides a simple framework to navigate C++ declarations using Python classes.

Repository: `https://github.com/gccxml/pygccxml`

pygccxml History

- The original author is Roman Yakovenko (2004-2011).
- Forked multiple times by different authors to add Python 3 support.
- In May 2014, Michka Popoff and the Insight Software Consortium revived pygccxml.

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New since 2014

- Mercurial to Git
- Travis-ci.org hook for Python 2.6, 2.7, 3.2, 3.3, 3.4 support.
- coverall.io hook for code coverage
- Docs on readthedocs.org
- quantifiedcode.com hook for code structure
- PEP8 compatible

pygccxml: API example

Input

```
namespace MyCoolProject {
  struct test_results {
    enum status {
      ok,
      fail,
      error
    };
    void update(
      const char * test_name,
      status result );
  };
}
```

Output

```
Name: update
Return type: void
Argument 0: char const * test_name
Argument 1: MyCoolProject::test_results::status result
```

Python

```
from pygccxml import parser
from pygccxml import declarations
# Snip --//-- Setup config object for castxml or gccxml
decls = parser.parse(["test.cpp"], config)
global_ns = declarations.get_global_namespace(decls)
project_ns = global_ns.namespace("MyCoolProject")
update_functions = project_ns.member_functions("update")
# There could be multiple functions with the same name (in c++)
for function in update_functions:
    print("Name: " + function.name)
    print("Return type: " + str(function.return_type))
    for i, arg in enumerate(function.arguments):
        print("Argument " + str(i) + ": " + str(arg))
```

Summary

- Generating an Abstract Syntax Tree is an important part of the wrapping process.
- The Abstract Syntax Tree is compiler-dependent because of the C preprocessor, standard library headers, and lines.
- CastXML captures the compiler-dependence and does complex parsing of C++.
- pygccxml is a Python interface to CastXML output

Resources I

Mailing list

http://public.kitware.com/mailman/listinfo/castxml

Repository

https://github.com/CastXML/CastXML