What Software Libraries Can You Use to Extract and Visualize Datasets?

Eduard Schreibmann

Department of Radiation Oncology and Winship Cancer Institute, Atlanta, GA
Aims

Beyond Scripting: What’s available out there?

Familiarize yourself with software options to select the library that is best suited for your project.

• Data extraction versus algorithm development.
• Should I invest in getting familiarized with a tool?
Options at a Glance

• Vendor-provided scripts great for simple data-analytics type projects
  • RaySation, Varian ESAPI, Varian Velocity, Elekta IQScripts
    – Provide direct access to your clinical system database, algorithms
    – Perfect for customized interfaces to your clinical system

• Development Libraries
  • ITK, VTK, RTK, TubeTK
    – Offered as code that has to be compiled for your computer configuration
    – Learning curve to understand the algorithms
    – Flexibility in creating your own algorithm

Existing functionality in your clinical system? Use scripts.
Want to build your own algorithm? Look at other libraries.
Scripts

Or how to quickly customize your clinical system
Sample Scripting: ESAPI

C# code to access objects in Varian’s database

Any value that you see in Eclipse can be accessed directly from code.
Sample Scripts (ESAPI)

• Extracting patient statistics from database

• Checking if a plan meets constraints

• Automating treatment planning
Data Extraction

- Automated extraction of RTOG protocols, treatment logs, dose and contour data for research projects.

- Input: A list of patients and what to extract

- Output: An Excel file to interpret

Scripts are perfect for batch extraction of patient statistics
Advantages

- **Access**: Your code has direct access to the clinical data.
- **Practical**: Easily integrates your with your clinical workflow.
- **Automation**: Automation of repetitive and tedious tasks best suited for scripting.

Disadvantages

- **Limited functionality**: Only algorithms available in the clinical system can be used.
- **Mostly Clinical**: Not a good tool for developing “your idea”. Use scripts for data-oriented projects.
Data Access
Or how to access any data in the database
Direct Database Access

Using C++ Builder to connect directly to the database. Other compilers can be used as well.

These tables connect directly to the database.

Prescriptions: Not accessible through scripting. Accessible through direct database access.
You may be able to get direct access to your vendor’s database.
Database Access Without Code

Just select your data table from a list.
Zero lines of code.

You can also run SQL queries against the database.
What Can Be Accessed?
Beyond Scripting

Or libraries to for developing your algorithm
Beyond Scripting

• **Open source:** Set of library offered as code. You can modify it in any way your like.

• **Don’t invent the wheel:** Set of standard building block performing common tasks that you can configure to your needs.

• **Feel free to modify:** You can change the code according to your project needs.

Here is the code. You have complete control.
Welcome to the National Library of Medicine **Insight Segmentation and Registration Toolkit (ITK)**. ITK is an open-source, cross-platform system that provides developers with an extensive suite of software tools for image analysis. Developed through extreme programming methodologies, ITK employs leading-edge algorithms for registering and segmenting multidimensional data. The goals for ITK include:

- Supporting the Visible Human Project.
- Establishing a foundation for future research.
- Creating a repository of fundamental algorithms.
- Developing a platform for advanced product development.
- Support commercial application of the technology.
- Create conventions for future work.
- Grow a self-sustaining community of software users and developers.

ITK provides leading-edge segmentation and registration algorithms in two, three, and more dimensions; it is distributed as an open-source software package.
Many Algorithms Available

There are thousands of algorithms implemented in ITK

Best suited for:
- Larger research projects.
- Need customization/changes over time.
- Likely to implement new algorithm or approaches.
- Commercial software development

There are thousands of algorithms implemented in ITK
Scripting versus ITK

• **Scripts sample applications:**
  - I don’t like the buttons in the commercial application
  - My colleagues would need to print customized reports
  - Would like to do some analysis with the clinical data

• **ITK sample applications:**
  - I want to develop a new segmentation algorithm for my images.
  - Need a customized image registration for my images
  - Want to develop an image reconstruction algorithm.
  - Some insight into images

**Scripting is easier to learn. ITK gives you more flexibility.**
A family of libraries

VTK: Visualization Toolkit

ITK: Insight Toolkit

Visualize images

Visualize meshes

Rapid prototyping

Multi-platform build system

All these libraries use same concepts and are connected.
Why I Like It?

• ITK and VTK are like Legos
  – ITK designed as building blocks from which customized applications are created.
Prototyping

Drag-drop interface to create customized algorithms from **building blocks**

**Medical Image Processing and Visualization**

MeVisLab represents a powerful modular framework for image processing research and development with a special focus on medical imaging. It allows fast integration and testing of new algorithms and the development of clinical application prototypes.
Why the Lego Analogy?

Libraries are a collection of “building blocks” that can be connected to your needs.

A filter (building block) that does some processing to an image

A connection between the building blocks
Example

The itkFlipImageFilter image filter will flip an image along a user specified axis.
Example

Easy to change setting to experiment on your images

Original image  Processed image

Filter options

Experiment with algorithms without writing code
Experimenting With Options

Experiment with algorithms without writing code
Example of simple pipeline to smooth a CBCT dataset
Once you prototyped your pipeline and settings, you can write corresponding code to build an application.
Template Code

It’s easy to readapt to code to new situations

ITK Definition:

```cpp
template< class TPixel, unsigned int VImageDimension >
Image< TPixel, VImageDimension >
::Image()
{
    m_Buffer = PixelContainer::New();
}
```

Your Code:

```cpp
int main (int argc, char *argv[])
{
    typedef itk::Image< long, 2 > SliceType; // a CT slice
    typedef itk::Image< long, 3 > VolumeType; // a CT volume
    typedef itk::Image< long, 4 > Scan4DType; // a 4D CT scan
    typedef itk::Image< float, 3 > DoseType;  // a dose volume
```
Deriving a new inherited filter

```cpp
template< class TImage>
class MyOwnImageFilter:public ImageToImageFilter< TImage, TImage >
{
    public:

    inline TOutput operator()(const TInput & A) const
    {
        const double input = ( static_cast< double >( A ));
        const double output = pow(input, 1.23456);

        return static_cast< TOutput >( output );
    }

```

Implementing your own equation, \( f(x) = x^{1.23456} \)
Catalog of ITK Features

• Image IO
• Image processing
  – Canny Edge
  – Hough Transform (lines/ellipsoids)
  – Variable Conductance Diffusion
• Geometry IO/representation/processing (Spatial Objects)
• Statistics
• Registration/Segmentation
• Numerics (VXL)
• Optimizers
• Finite Element Simulation

There are thousands of algorithms implemented in ITK
Sample Project: Radiomics

**Simple voxel statistics:** minimum, maximum, mean, standard deviation, variance.

**Image filters:** Canny, Laplacian, Sobel, derivative, Hessian, Sharpening, gradient magnitude, HMinima, HMaxima, HConvex, Hconcave.

**Shape statistics:** elongation, perimeter, radius, flatness, roundness, volume, etc.

**First order textures:** energy, entropy, inverse difference moment, inertia, cluster prominence, cluster shade.

**Second order textures:** short run emphasis, long run emphasis, grey level non-uniformity, run length non-uniformity, low gray level run emphasis, high gray level run emphasis, short run low grey level emphasis, short run high grey level emphasis, long run low grey level emphasis, long run high grey level emphasis.

Sample features extracted with ITK: (a) Original CT (Figure 1). (b) Gradient magnitude. (c) HConvex with a threshold of 500 HU (d) Homogeneity texture (e) Laplacian sharpening.
Where To Find Help

- Visit the website
- Download the software
- Join the mailing list
- Attend a training course
- Purchase support
- Buy the ITK Software Guide

![ITK Classes](classes.html)
Visualization Tool Kit (VTK) is a software system for computer graphics, visualization and information visualization. It is developed by Kitware and used to create applications that visualize large complex datasets and build interactive scientific visualizations. VTK supports a wide range of data formats and is designed to be highly modular and extensible. Its primary purpose is to provide algorithms to visualize the data.
Paraview

Open-source application to visualize meshes
VolView

Open-source application to visualize images
Thank you

www.mevislab.de

www.volview.org

www.paraview.org

www.itk.org

www.cmake.org