SimpleITK Status

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MAYO CLINIC

Today’s Plan

```
$ cat .plan
Build a better mousetrap
Rule world
```

- Discuss viewpoints
- Survey
- Coffee cup
- Decide
- Go home and code

Problem

```
// Setup image types.
typedef    float    InputPixelType;
typedef    float    OutputPixelType;

typedef itk::Image< InputPixelType,  2 >   InputImageType;
typedef itk::Image< OutputPixelType, 2 >   OutputImageType;

// Filter type
typedef itk::DiscreteGaussianImageFilter<
              InputImageType, OutputImageType >  FilterType;

// Create a filter
FilterType::Pointer filter = FilterType::New();

// Create the pipeline
filter->SetInput( reader->GetOutput() );
filter->SetVariance( 1.0 );
filter->SetMaximumKernelWidth( 5 );
filter->Update();
OutputImageType::Pointer blurred = filter->GetOutput();
```

Listing 1: Discrete gaussian filter implemented in ITK

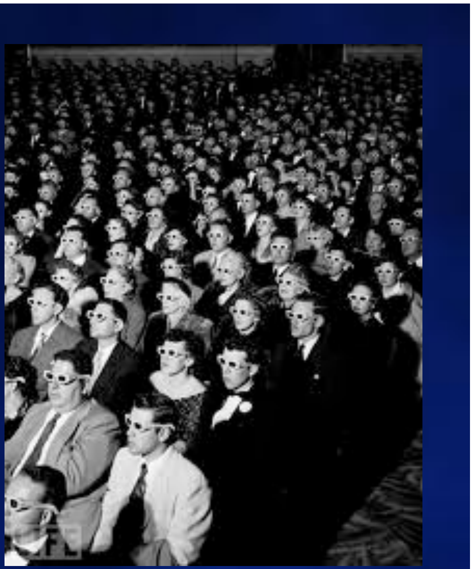
```
% Filter image I with a gaussian of sigma 1 with a radius 5 kernel.
blurred = imfilter ( I, fspecial ( 'gaussian', 5, 1 ) );
```

Listing 2: Discrete gaussian filter implemented in Matlab

Complexity

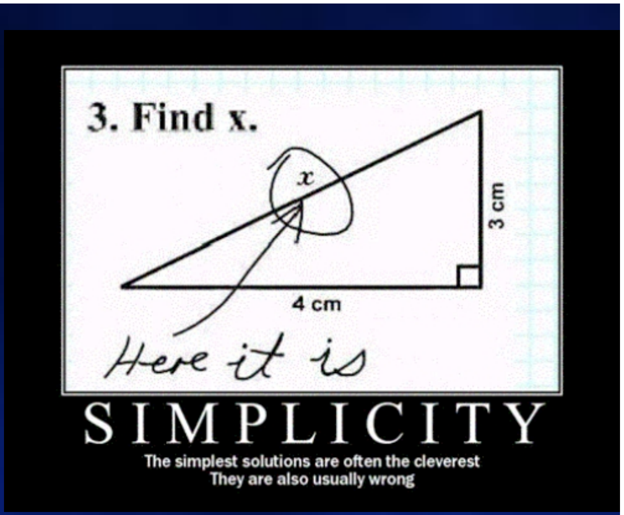
- Powerful but complex
- Steep learning curve
  - ever had 2 pages of compile errors?
- C++
- ITK often unused
  - But it’s the best...

Audience



- Students
- Grad students
- Researchers
  - Microscopy
  - Computer vision
  - Remote sensing
- Application developers

Simplify


3. Find x.
x
3 cm
4 cm
Here it is
SIMPLICITY
The simplest solutions are often the cleverest
They are also usually wrong

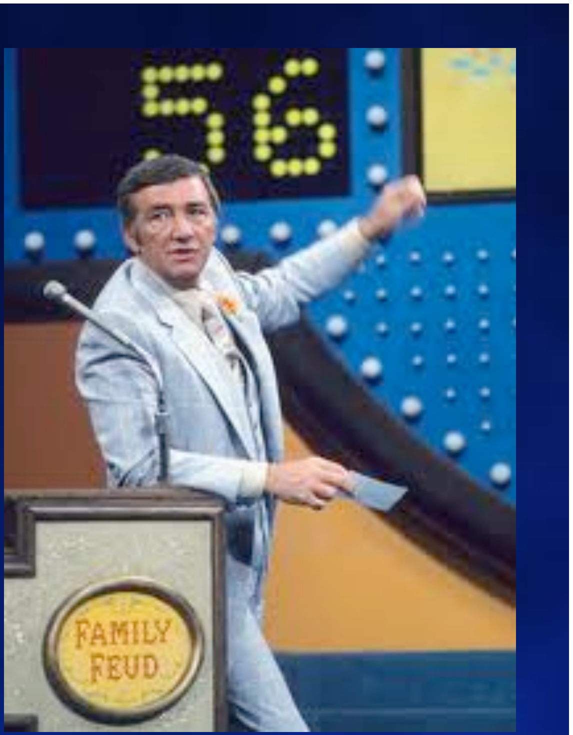
- As simple as possible...
- ...but no simpler
- Simple for:
  - users
  - application developers
  - SimpleITK developers

Goals

- Simple
- “On ramp”
- Wrapping
- Integration
  - In apps
  - With ITK, VTK, etc
- Extensible

Survey Says!

- Compiled packages
- Documentation / Examples
- 3D & 4D
- Out of core processing
- Object model
- char, short, float/double, vector(?)
- Visualization



Gabe Hart

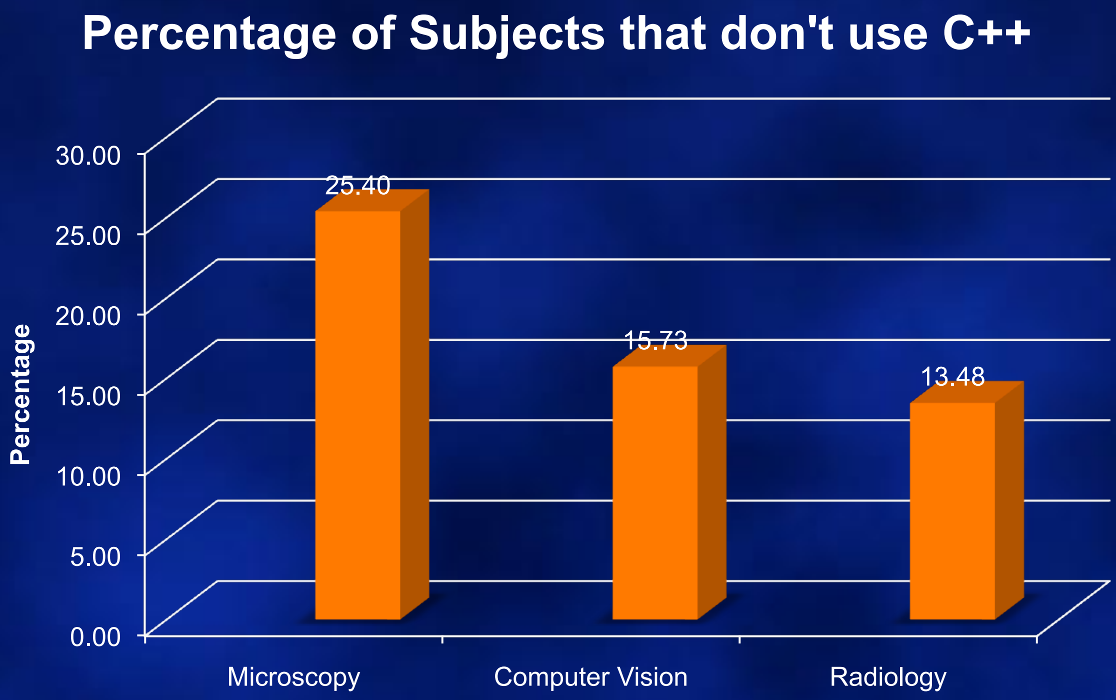
Getting inside their heads

- 253 participants (11/6/10)

- Non-C++ users:
  - 21.34% (54 participants) have never used or don't feel comfortable using C++
    - Specific distribution: 16 + 38
  - 51% (28) of non-C++ users have used ITK
  - 26 have never used ITK

- Non-ITK users:
  - 17.78% (45 participants) have never used ITK
  - 207 have used ITK
  - 44.44% (20) of non-ITK users are C++ users

C++



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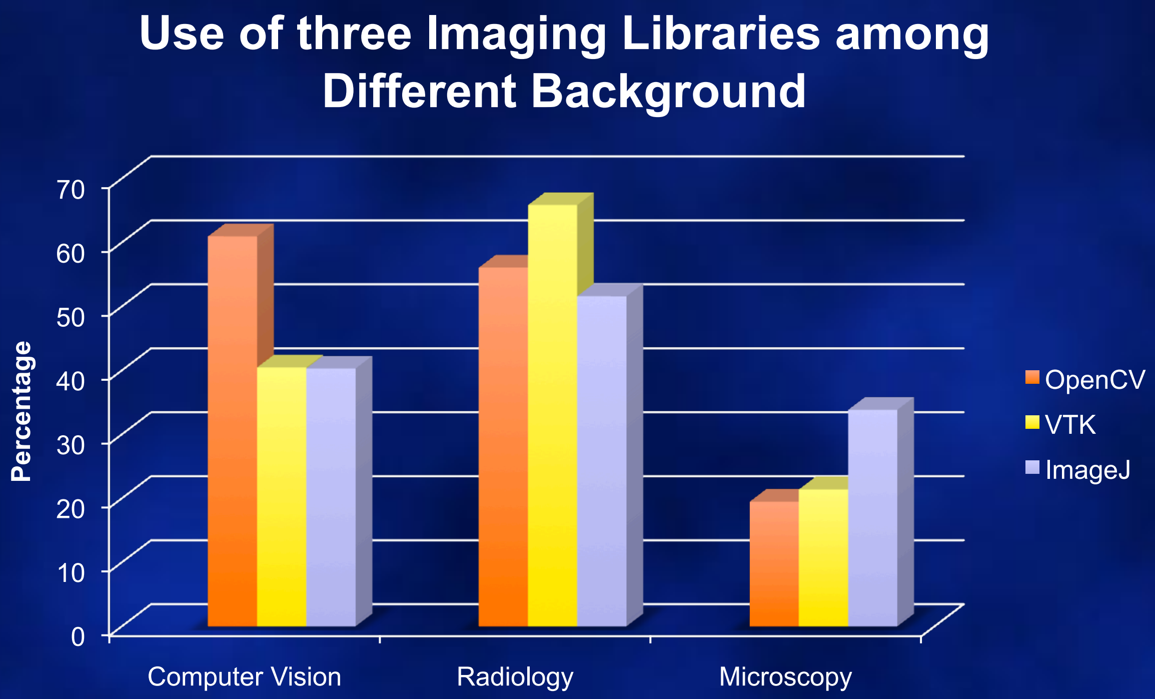
Competition



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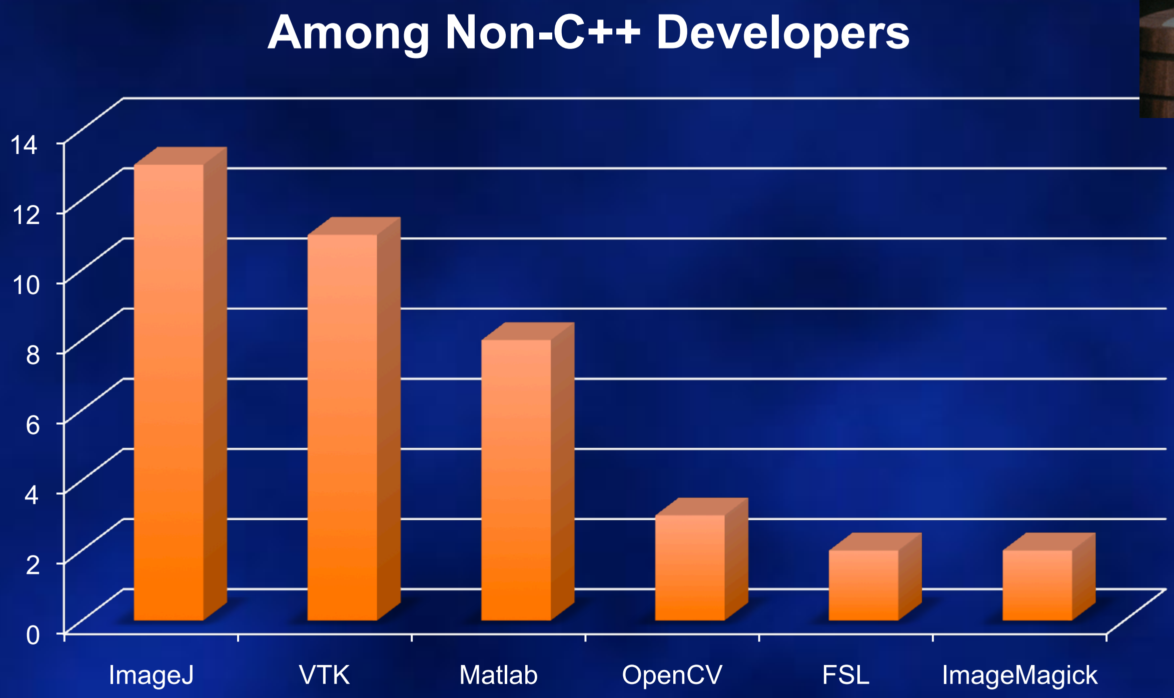
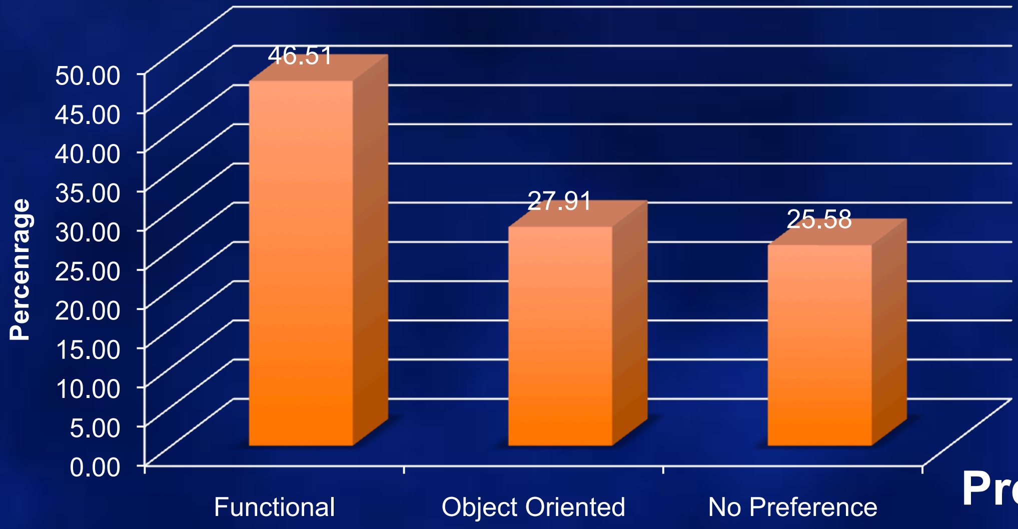
Competition



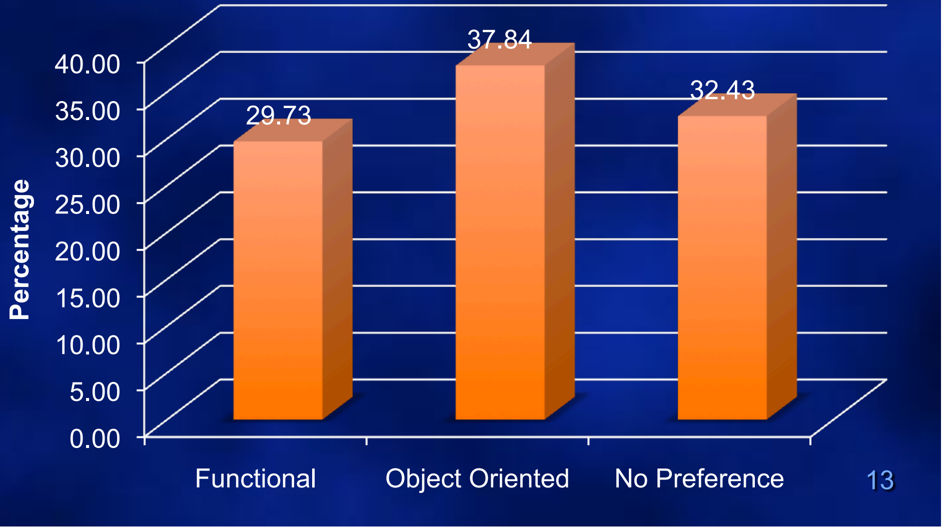
Note that all of the top libraries / applications among non-C++ developers provide processing and visualization.

Functional / Objects

Preference Among Non-C++ Programmers



Preference Among Non-ITK Users



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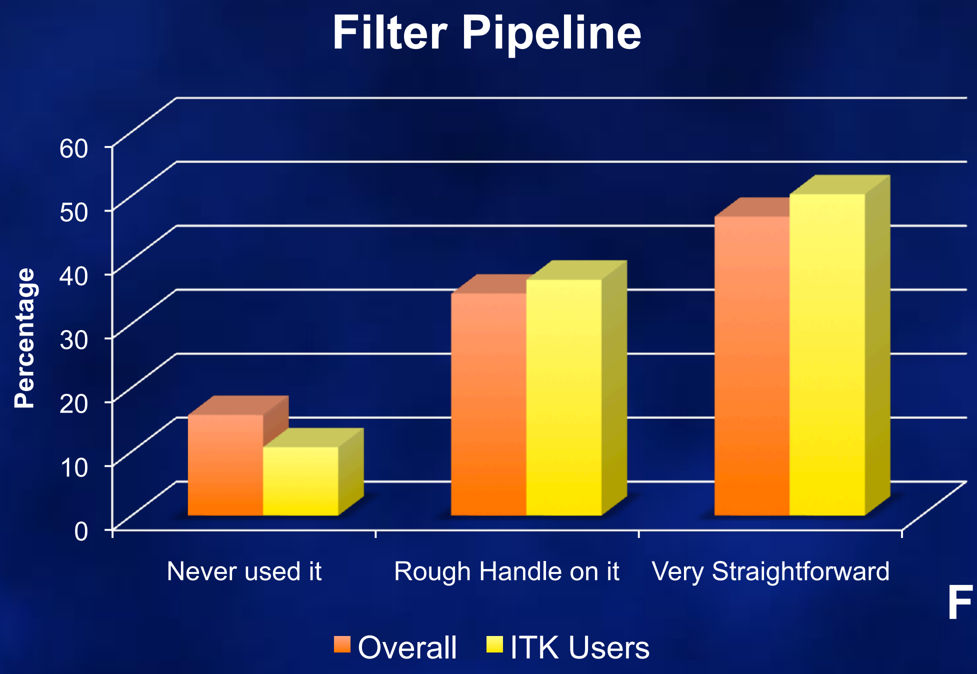
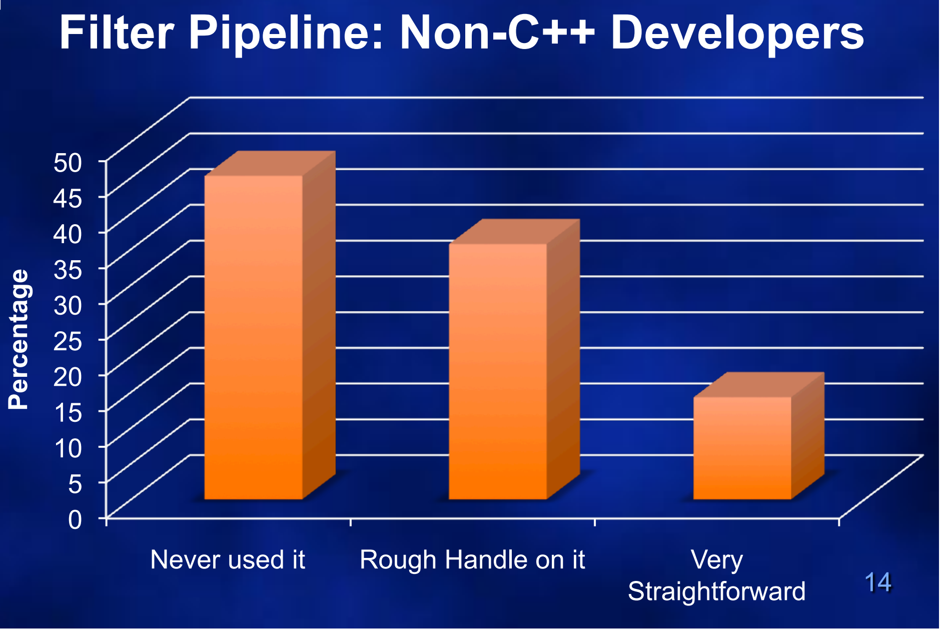
Pipeline

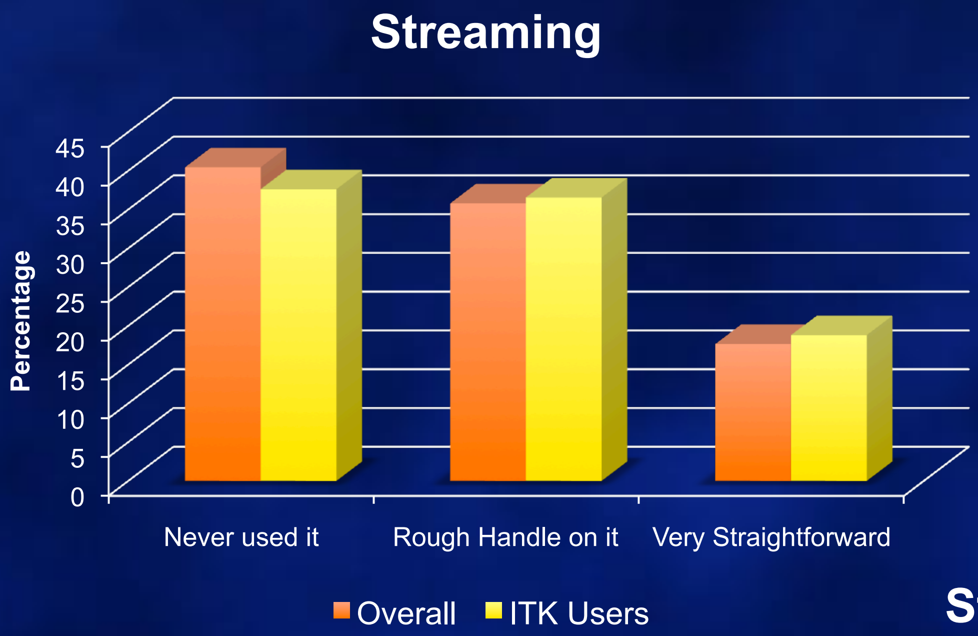


Note:

Most non-C++ users (including the 51% that have used ITK), don't understand the pipeline.

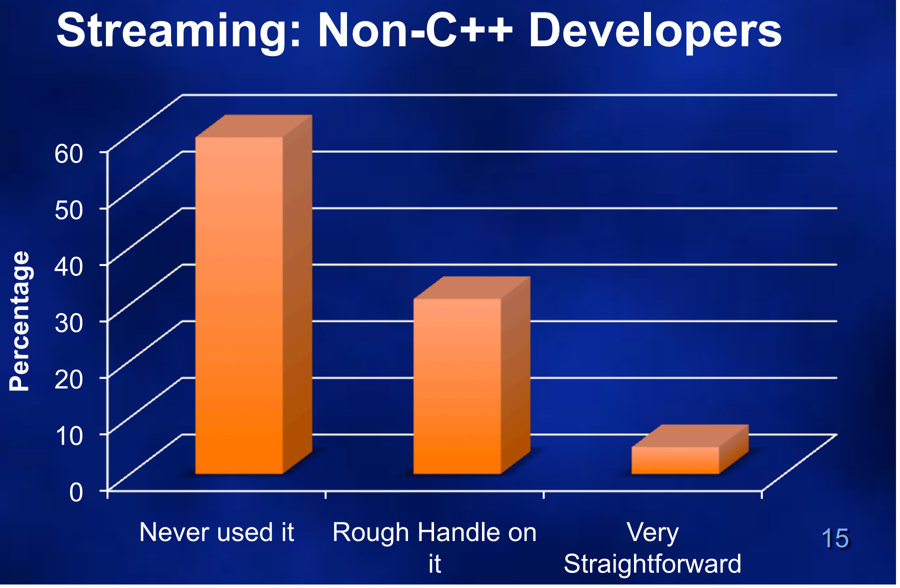


Streaming



Note:

Most ITK, non-ITK, and C++ users don't have a clear understanding of streaming



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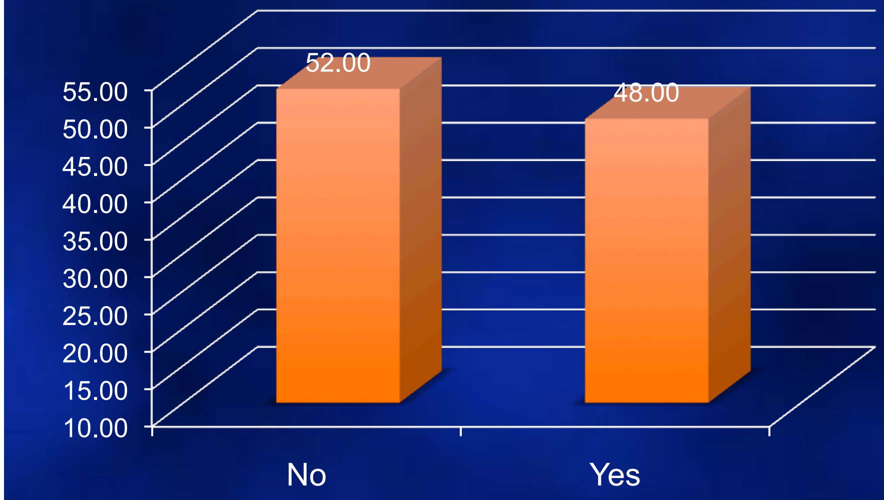
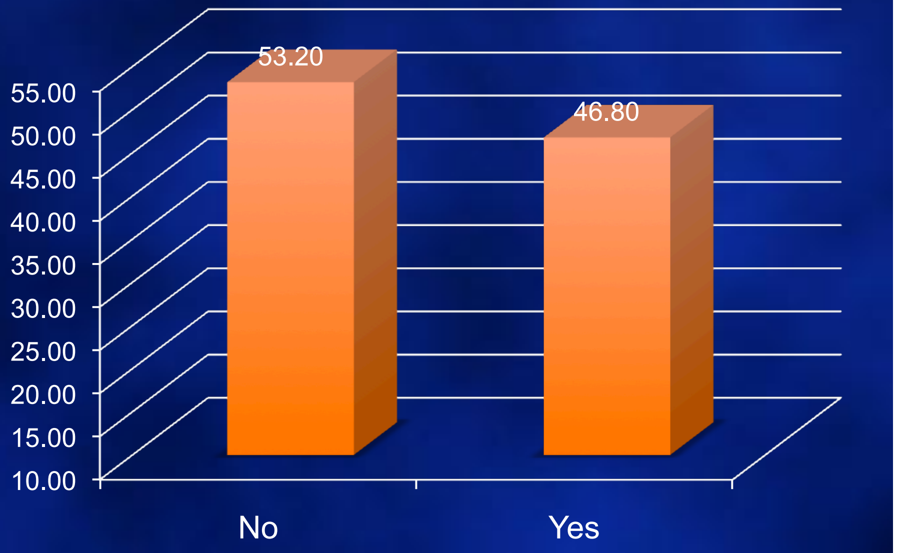
Out-of-core

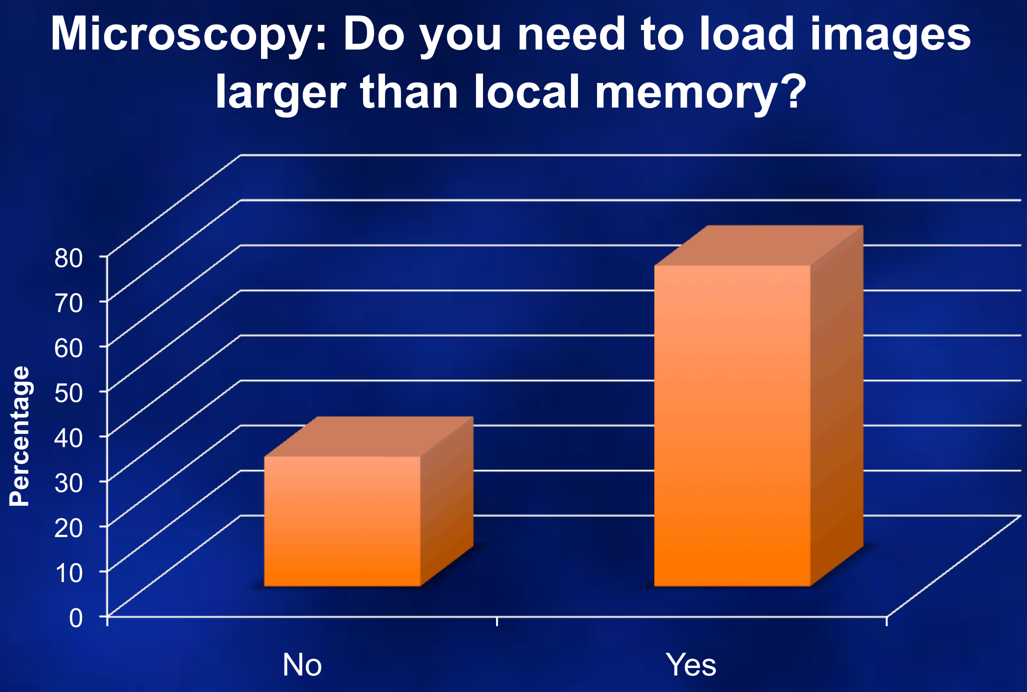
Non-C++ Users: Do you need to load images larger than local memory?



ITK Users: Do you need to load images larger than local memory?



Out-of-core


Microscopy: Do you need to load images larger than local memory?
Percentage
80
70
60
50
40
30
20
10
0
No
Yes

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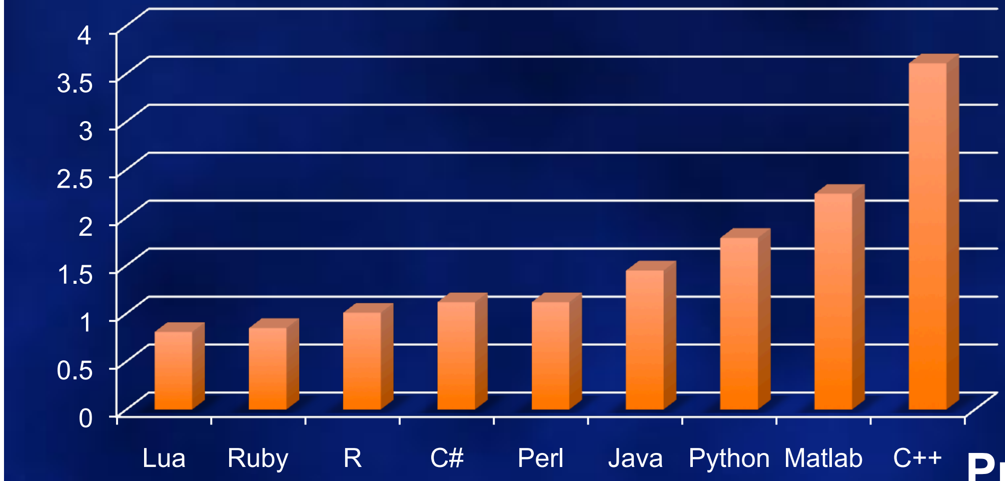
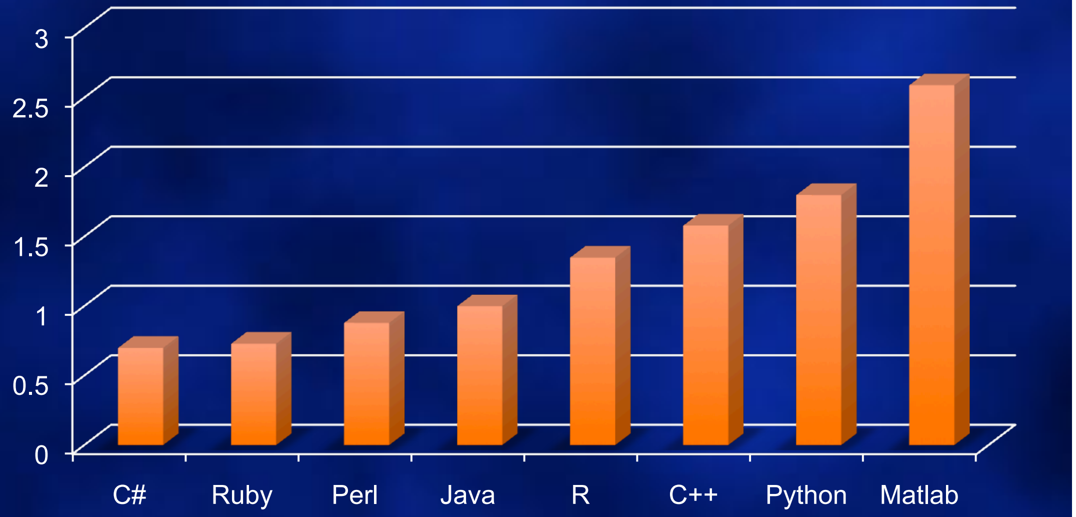
Languages

Preferences: C++ Experts



Preferences: Non C++ Developers



Q:

Can we say that Matlab, Python, C++, Java, and R are the most important programming languages?

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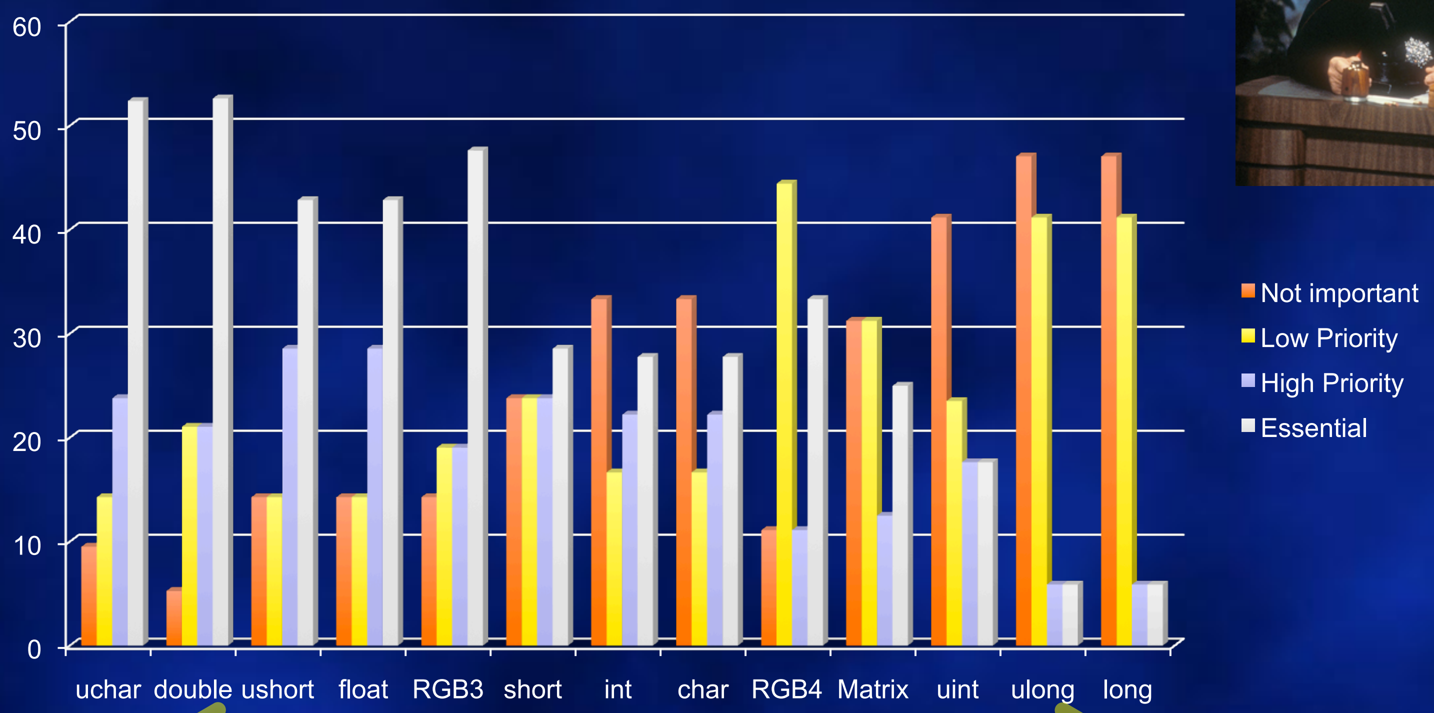
Pixel Types

Pixel Type: Non-ITK Users



More important ⟷ Less Important

Top 6 (Non-ITK users)

1. uchar
2. double
3. ushort
4. float
5. RGB3
6. short

Top 6 (Overall)

1. float
2. uchar
3. ushort
4. short
5. double
6. matrix

Comments: defaults

- "Important to give users relatively straightforward advice on algorithm…"
- "Simple defaults with optional alternatives"
- "I generally want to be able to try something off the shelf with sensible defaults"
- "Sensible defaults should be provided to avoid long code"
- "Full flexibility is needed but a good selection of default parameters for all modules would be also important"
- "initialized with reasonable default components"

Comments: GUI

- “offer both...a GUI … and build scripts from there”
- “connect display to view intermediate images”
- “handling ability to visualize quickly (even at run time) images and histograms”
- “A GUI to build up the application pipeline by arranging icons of filters and I/O connectors”
- “visual tool for connecting filters to a pipeline

Comments: Complexity

- “writing ITK codes can be a complex task but with more examples and a thorough documentation these difficulties can be overcame”
- “One good way to compromise is more flexible but with lots of example code that can be cut-and-pasted for typical applications.”
- “Actually I think much of the motivation for SimpleITK could go away, if someone updated + improved the documentation”
- “some of the image filters modules are not sufficiently documented”
- “Lots of sample code that can be modified for specific purposes”

Ouch

- “I am not using ITK for registration purposes, and this is because of the complexity of it”
- “Extensive use of templates makes debugging difficult in VisualC++”
- “Most of filter called *VectorImageFilter are in fact not able to process itk::VectorImage ... This is confusing and sometimes frustrating”
- Ability to open differing file formats (dimensions, data types) without all the stupid c++ template nonsense.

Decisions

- API
- Datatypes
- Dimensionality
- Pipeline?
- Out of core processing
- Wrapping
- Distribution

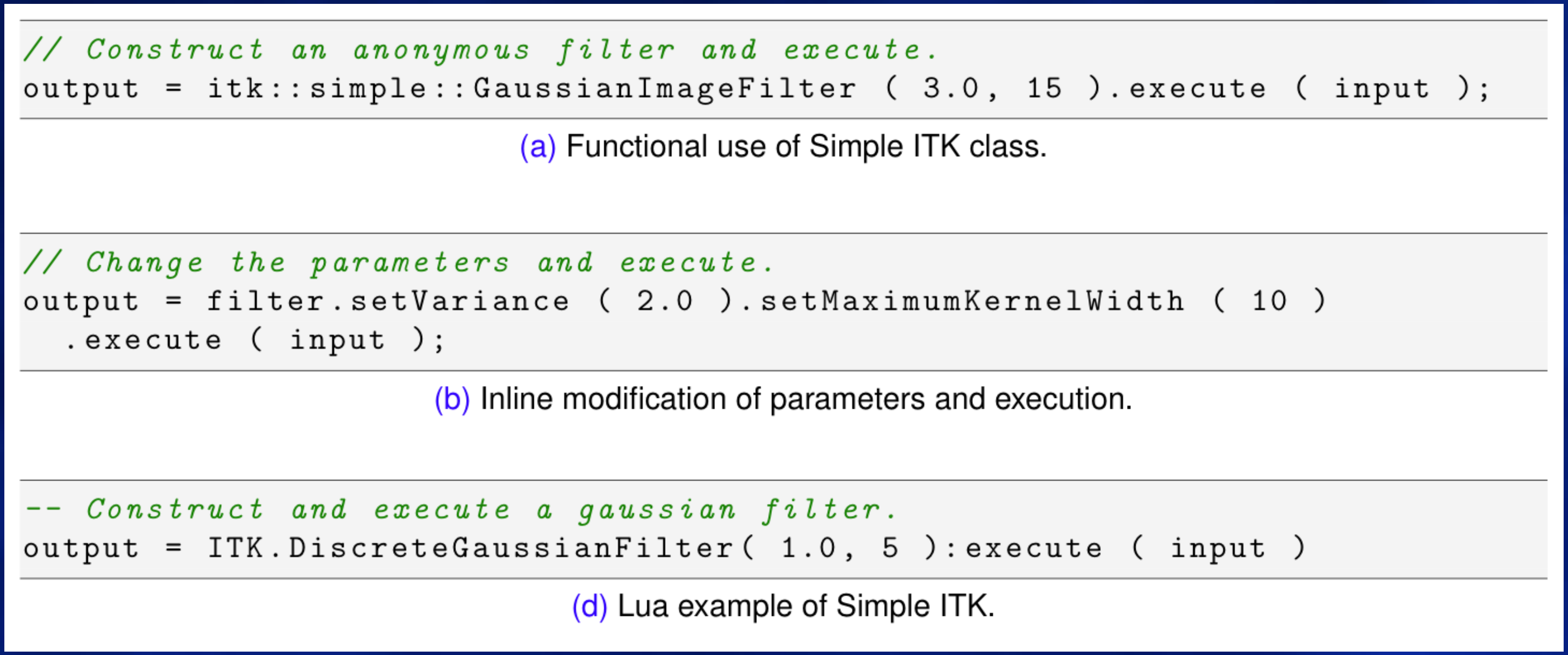
Coffee-cupping

Strawman Proposal

- Object model
- 3D images (& slice-by-slice for 2D)
  - 4D as vector of images, labelmap class
  - char, short, float (double?)
- No exposed pipeline
- Out of core orchestration framework
  - VOI readers/writers
  - Call list of filters / handle boundaries
- SWIG wrapping

API

- **Procedural / functional?**



```
// Construct an anonymous filter and execute.
output = itk::simple::GaussianImageFilter ( 3.0, 15 ).execute ( input );
```

(a) Functional use of Simple ITK class.

```
// Change the parameters and execute.
output = filter.setVariance ( 2.0 ).setMaximumKernelWidth ( 10 )
  .execute ( input );
```

(b) Inline modification of parameters and execution.

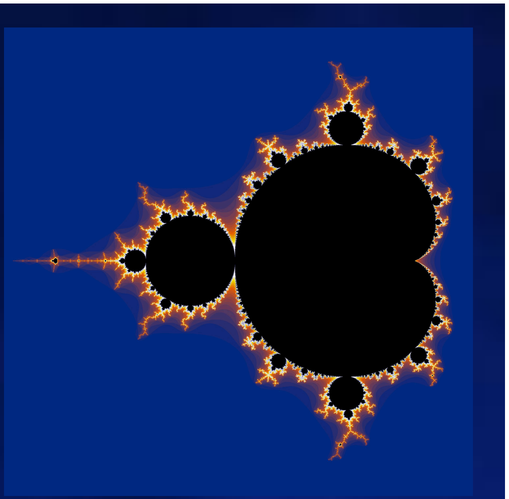
```
-- Construct and execute a gaussian filter.
output = ITK.DiscreteGaussianFilter( 1.0, 5 ):execute ( input )
```

(d) Lua example of Simple ITK.

Alternative

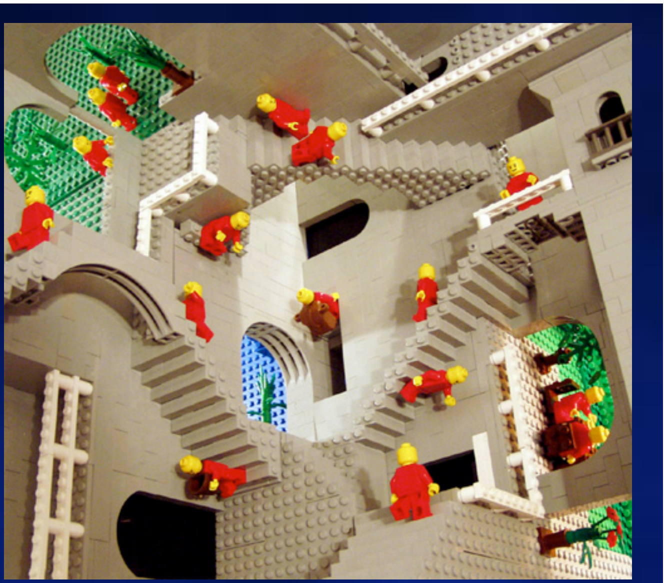
- C++ should be the same as wrapped languages
- Accessibility to as many developers as possible
  - Python, Java, and non-templated C++ programmers
- VTK wraps into python, java, C#, Tcl
  - The C++ code is 90% available
- As VTK grows the simple VTK grows
- What is different than ITK?
  - Templates!
- Custom API would get old and not maintained
- For this to “stick” we would have to drink our own beer

Data types



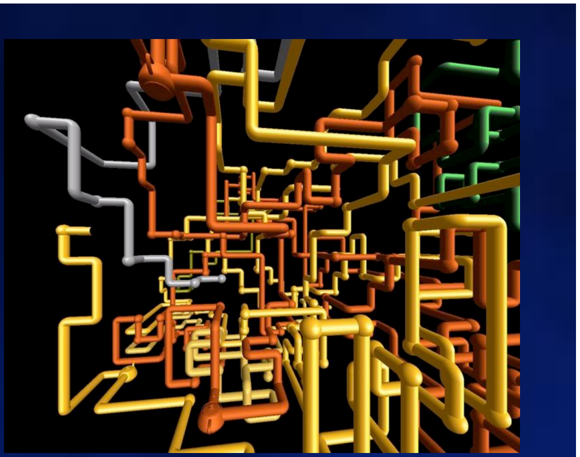
- Which to support?
  - Scalar in all filters?
  - Vector in limited set?
- How to support?
  - Dynamic loading?
  - Compile time configured?
  - Template meta programming?
  - Macros?

Dimensionality



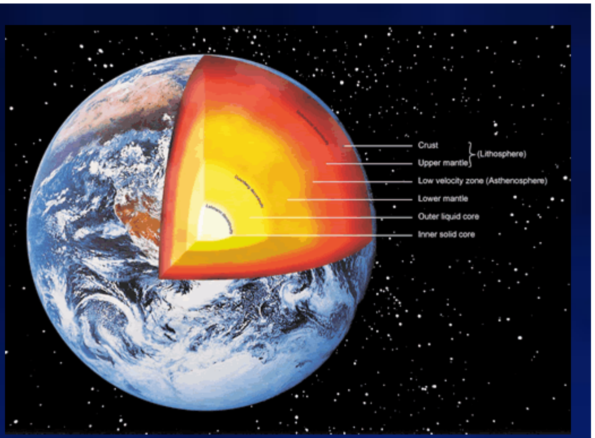
- 3D critical
- 4D nice
- How to support?
    - 4D == 4D itk::Image?
    - 4D == vector of 3D images?
    - 4D == 3D with vector pixels?

Pipeline



- Unnecessary complexity
- Utility in streaming
  - Not (fully) implemented in ITK

Out of core processing



- Essential
  - ITK Pipeline?
  - OpenCL model?
    - single pixel kernel pixel
    - called for all pixels
    - “orchestration” framework

Wrapping

- SWIG
- Languages
  - Matlab
  - Python
  - Java
  - C#
  - Others: Tcl, R, Perl, Ruby...
- Interface to WrapITK a “nice to have”

Distribution

- Binary
  - Matlab (somehow)
  - Python egg
  - Java jar
  - C++ lib/dll/so & include
- Source
  - Less useful

SimpleITK Status

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