Image-based measurements

Introducing SimpleITK/R

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Background

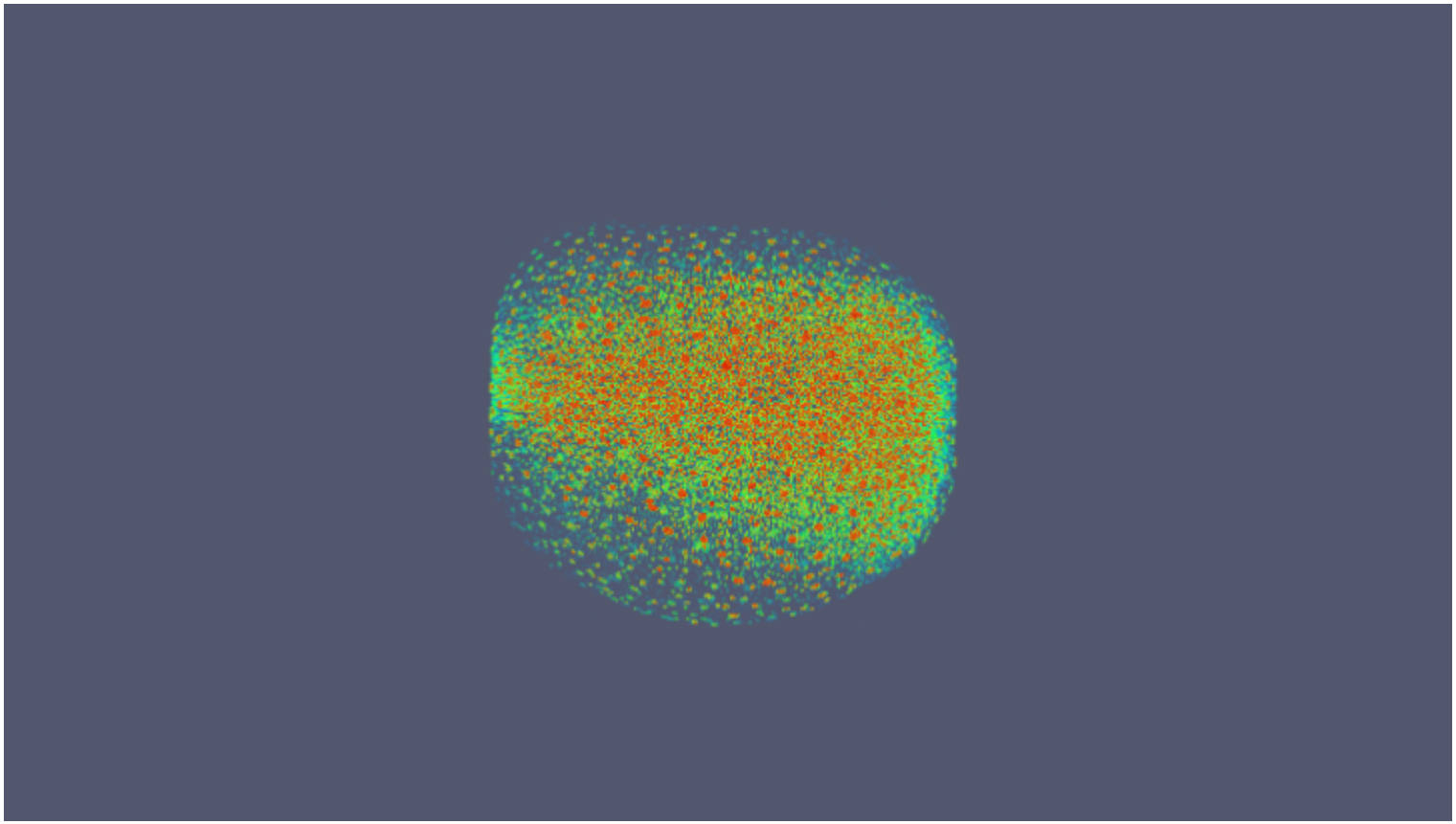
- Raw data is often acquired in the forms of images.
- Lots of advantages - archivable, can be reprocessed.
- Acquistion can often be automated.
- Explosion in digital camera technology means that it is relatively easy to include image acquistion in all sorts of experiment.
- Almost always need to do some sort of analysis of the image data to extract the information of interest - *image processing*, *image analysis*, *computational image analysis*, *feature extraction*, *image segmentation*

Sources of image data

- Massive range of instruments able to acquire images:
  - Digital cameras pointing at any scene you like (2D or 2D + time)

Sources of image data

- Massive range of instruments able to acquire images:
  - Digital cameras with automated microscopes (2D or 3D + time + label)



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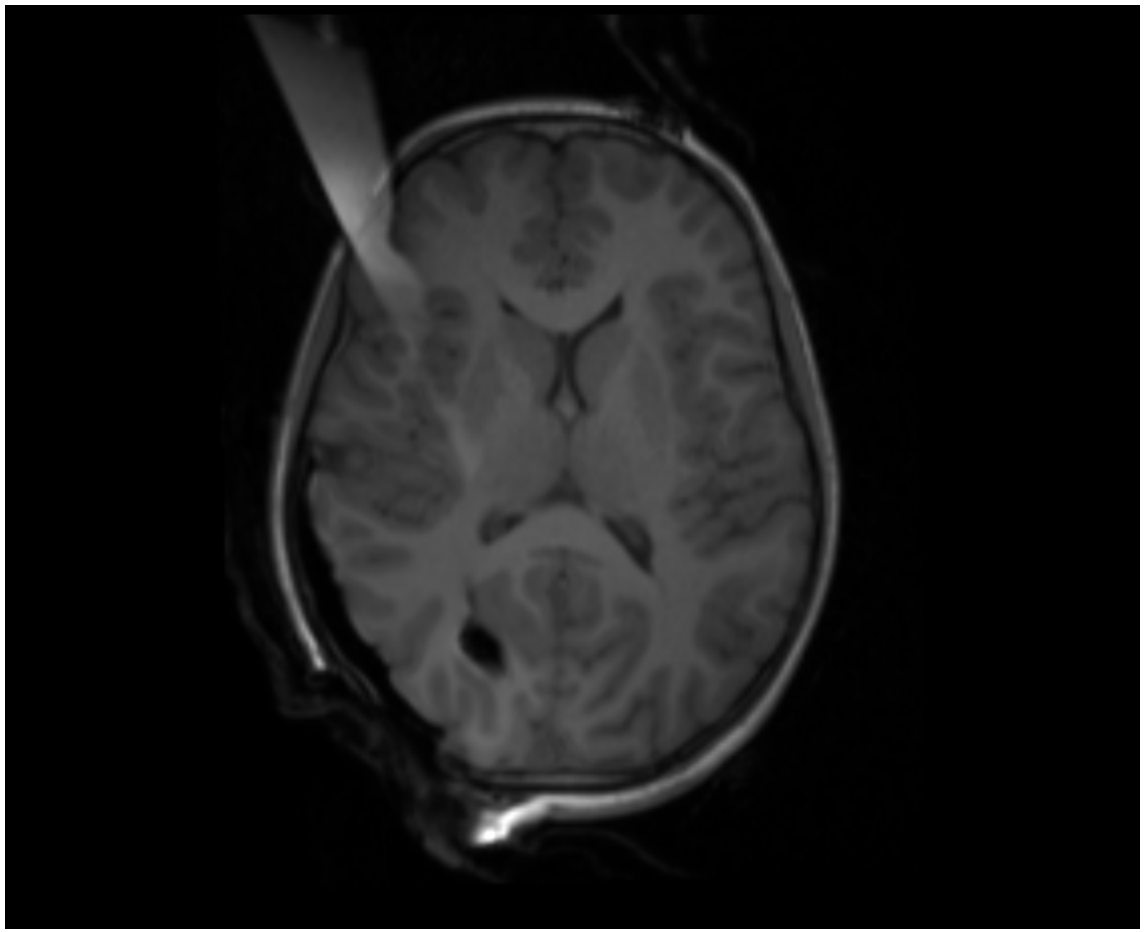
Sources of image data

- Massive range of instruments able to acquire images:
  - Medical imaging CT or MRI (3D + time + other stuff)



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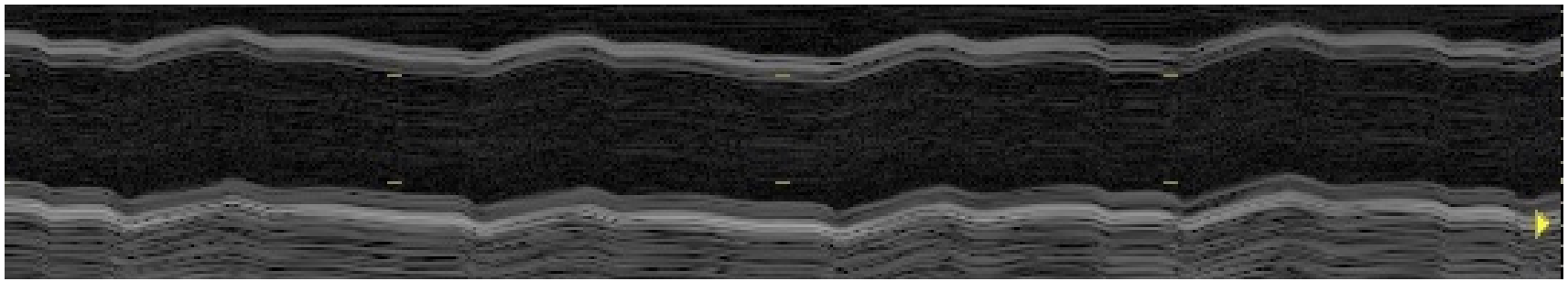
Sources of image data

- Massive range of instruments able to acquire images:
  - Ultrasound



Sources of image data

- Massive range of instruments able to acquire images:
  - Range images
  - Multispectral images
  - Stereo
  - Crystal structure
  - etc

Analysis approaches

- Lots of specialised software to perform analysis, but mostly only applicable to one application domain
  - Many packages for neuroimaging analysis (FSL, SPM, AFNI etc)
  - Tools for morking with microscopy data (Fiji)

Thus, you are usually on your own if someone comes in with new data.

Sensible to use existing components to build any new application - thankfully there are now big, open source, component libraries available.

Interpreter environments, like matlab and python, with imaging capabilities, are very useful when building new applications.

R has been missing a general purpose imaging toolkit.

Components

There are a range of standard tools for image analysis, and combining them in different ways will give useful results to many problems.

Types of measurement

- Count objects (e.g. cells)
- Measure areas/volumes (cells again, brain tissue volumes)
- Detection of something - e.g a crack (wood, roads, eggs)
- Tracking.
- Orientation.

Processing stages - how to find things to measure

Finding (and delineating) objects of interest can be very challenging.

Some preparation in terms of experiment design can make a huge difference.

- Filtering (smoothing, edge enhancement, morphological filtering)
- Segmentation/classification - thresholding, intensity based multiclass, level sets, watershed.
- *component* characterisation.

The Insight Toolkit (ITK) for image segmentation and registration

ITK is a long running, NIH funded, project to make high quality, open source image analysis components.

- Encourage reproducability.
- Provide a well engineered framework for development (smart pointers, multi-threading, etc)
- It is a C++ component library. Steep learning curve.
- **Huge** - 1800+ classes.

Used in non medical domains and is the basis for a range of applications.

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SimpleITK

- Uses even fancier C++ code to hide the complexity of ITK.
- Idea is to make C++ level programming easier and make wrapping with interpreted languages more practical.
- Uses a largely automated approach to wrapping using JSON and swig (important for long term maintenance).
- Support for *python*, *perl*, *ruby*, *csharp*, *java*, *lua*, *tcl*
- I've been working on the R version.
- **300 classes** - way more capability than any commercial offering I'm aware of.

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Infrastructure - swig developments

- Swig has had some R support for ages, but hasn't been particularly popular.
- Support for automatic conversion of vectors has been added.
- Improved support for enums.
- Tuning garbage collection for SimpleITK.
- Does a pretty good job of wrapping C++ code in something like reference classes.

General structure

- Images are pointers (external references) to the C++ objects.
- Operator overloading and generic operators to make them act like arrays.
- Can import/export to arrays.
- Viewing is via external application (customisable).

Installation - linux and mac

Requires *cmake*..

```
## many hours of building
devtools::install_github('richardbeare/simpleitkRinstaller')
```

Notebook demo..